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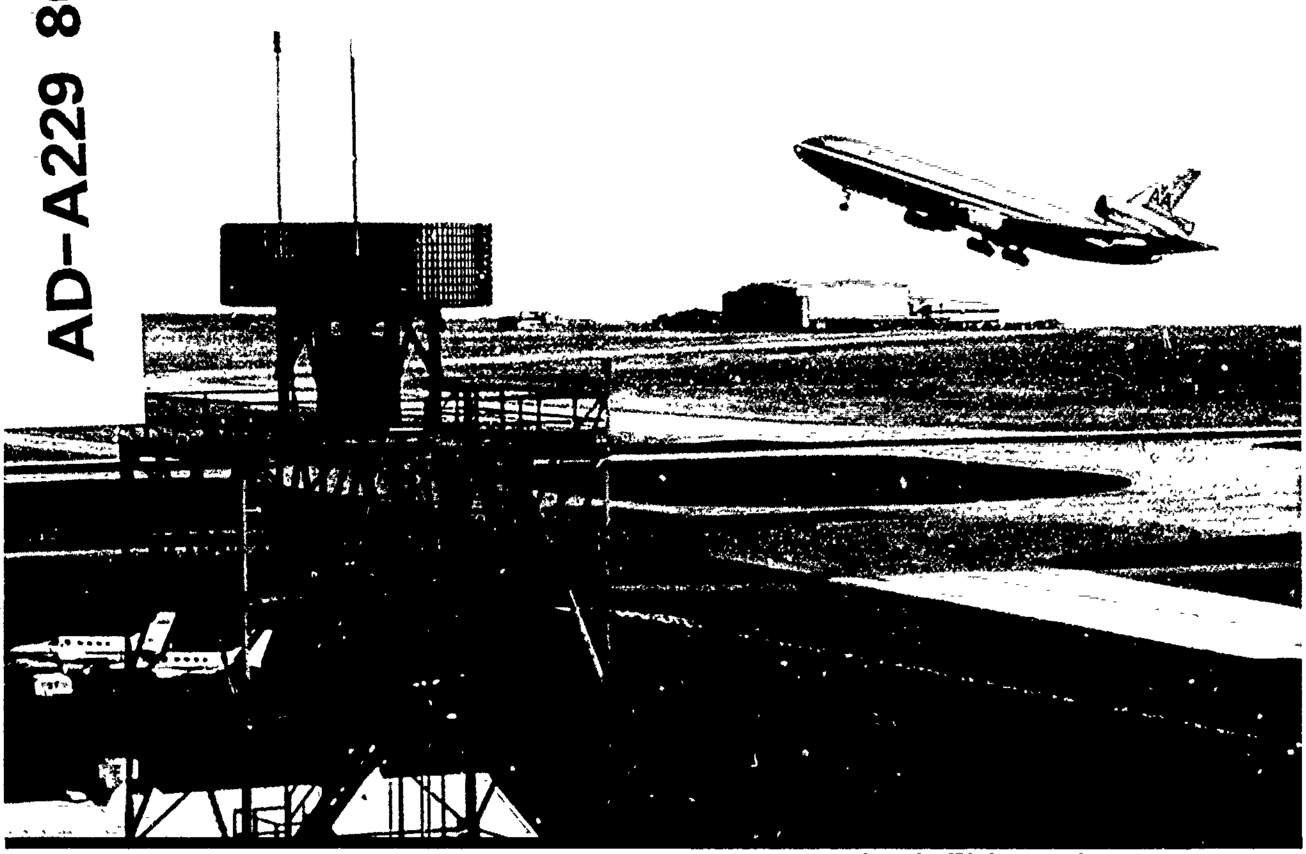
U.S. Department
of Transportation

Federal Aviation Administration

1990 - 91 Aviation System Capacity Plan

DOT/FAA/SC-90-1



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U.S. Department of Transportation
Federal Aviation Administration

Office of the Administrator

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Washington, D.C. 20591

DEC 20 1990

RECIPIENTS OF THE 1990-91 AVIATION SYSTEM CAPACITY PLAN

Since 1986, the Federal Aviation Administration Capacity Office has published the Airport Capacity Enhancement Plan. In recognition of the comprehensive nature of the national aviation system, the enclosed new Aviation System Capacity Plan presents an integrated analysis of airport capacity programs, airspace procedures, airspace design, and technology development. The plan will help us ensure that the improvements we make to the aviation system support the growth in capacity that is forecasted over the coming years.

The plan serves three goals:

- o It establishes the impact of planned or technologically feasible development at airports that have or are projected to have delay problems;

- o It identifies "underutilized airports" with commercial service that are within 50 miles of airports forecasted to have delay problems where shifting operations may result in significant delay reductions; and

- o It identifies new connecting hub airports which could be used to shift air service from traditional hub airports and to reduce delays.

Increasing system capacity requires the combined efforts of the FAA, the aviation industry, and State and local communities. This plan will serve as a blueprint for all our efforts to enhance system capacity to ensure that the quality and cost of air service continue to improve.

Sincerely,

J B Busey

James B. Busey
Administrator

Enclosure

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16. Abstract

This is a comprehensive review of the Federal Aviation Administration's program to improve the capacity of the National Air Transportation System. The Plan identifies the causes and extent of capacity and delay problems currently associated with air travel in the U.S., and outlines various planned and ongoing FAA projects that will reduce the severity of the problem in the future. The major areas of discussion are: 1) Airport Development; 2) Airport and Airspace Capacity Improvement; 3) Technological Improvements; and 4) Marketplace Solutions. Keywords; *terminal flight facilities. (EMK)

17. Key Words

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Summary

The Aviation System Capacity Plan is intended as a comprehensive "ground-up" view of aviation system requirements and development. The first step in problem-solving is problem definition. This plan defines the aviation capacity problem in terms of flight delays rather than dealing with the more abstract "capacity" definition. While it is relatively simple to compute an airport's hourly throughput capacity (the *average* number of flight operations which can be handled in IFR or VFR for a given runway operating configuration), annualizing those numbers is more difficult. The term "congested airport" is a term of art, not science.

This plan states that over 20 major airports each currently experience more than 20,000 hours of annual flight delay. That number is forecast to approximately double in a ten-year time frame in a "do nothing" scenario with no improvements in capacity.

While it is common for demand to exceed hourly capacity at some airports, there are ways of accommodating that demand. First, air traffic management regulates departures and slows down en route traffic, so some delays occur as flights are shifted into times of less congestion. This is a temporary solution because as traffic increases at a given airport, there will be fewer off-peak hours into which flights may be shifted. A survey of ten major airports has shown that hourly flight operation variance is only 7% from 8 a.m. to 7 p.m.

Another demand management technique is to encourage smaller aircraft to use reliever airports. Of the forty-one forecast delay-problem airports, approximately one-third have 25% or more general aviation operations. It might be assumed that there could be significant forecast flight-delay reduction if a percentage of those operations could be shifted to reliever airports. However, several forecast delay-problem airports have fewer than 10% small aircraft operations. It could be argued that those airports are largely "relieved" and further diversion of operations to reliever airports would be of marginal significance in flight delay reduction.

This plan identifies many "under-utilized airports" with commercial air service and which are within 50 miles of forecast delay-problem airports. The natural shifting of demand and operations to those airports could result in significant flight delay reduction.

The Aviation System Capacity Plan also identifies potential new connecting hub airports which could serve to decentralize air service at traditional connecting hub airports and reduce flight delays. Economics will dictate if, and how fast, new connecting hub airports are developed. However, in the 1980's several airline operators chose to rapidly develop under-utilized airports to form connecting hubs that improved their networks.

Having identified forecast delay-problem airports, this plan attempts to document planned or technologically feasible capacity development at those airports. This is where the "ground up" view begins. FAA is co-sponsoring airport capacity design teams (task forces) at major airports to assess how airport development and new technology could "optimize" capacity on a site-specific basis. This results in a "good news/bad news" scenario at some airports. For instance, the proposed capacity improvements at Miami International Airport are forecast to reduce potential flight delays by 30-40,000 hours annually at a level of 550,000 annual operations (forecast sometime beyond year 2000). However, since Miami has no new runways planned, residual annual delays are forecast to be 40-50,000 hours with 550,000 operations, two to

three times the current level of flight delays. This gives rise to the planning for a new commercial airport in Dade County, currently underway.

The largest capacity gainers at airports are new runways. This plan documents more than 60 new runways or major runway extensions planned or proposed at the top 100 airports. Projects were completed in 1989 at San Jose, Orlando, Ft. Lauderdale, Nashville, and Dayton. Significant capacity gains will be achieved by the new runways at Orlando and Nashville. Seventeen runway projects are scheduled for completion in 1990-91, including new runways at Indianapolis and Cincinnati.

Moving from the "ground-up," this plan identifies new terminal airspace procedures which will increase capacity for existing or new runway configurations. Of the top 100 airports, 26 could benefit from improved independent parallel IFR approaches, 21 could benefit from improved dependent parallel approaches, 55 could benefit from non-parallel IFR approaches, and 14 could benefit from triple IFR approaches. Demonstration programs are underway for these new airspace procedures.

Some of the new airspace procedures and airport capacity projects require new technology and new systems and equipment. More than two dozen programs are currently underway in FAA's R,E&D and F&E programs to provide that new technology. This plan outlines the progress of those programs.

Many of the technology programs are designed to reduce the capacity differential between IFR and VFR. The difference in VFR separation standards and IFR separation standards required because of reduced visibility in bad weather, causes 60% to 70% of flight delays. If we can achieve or surpass the capacity levels that we can now achieve visually by the use of new electronic guidance and control equipment, that differential can be improved. If two or three flight arrival streams can be maintained in IFR, rather than being reduced to two or one arrival stream(s), significant gains in capacity may be achieved.

Some of the technology programs are designed to provide more information to air traffic controllers and pilots with improved visual displays and non-voice communications. Those programs will allow for less new capacity than the programs providing multiple flight arrival and departure streams. The capacity gains are, nevertheless, significant.

Some of the technology programs are designed to improve the efficiency of aircraft movement on the airport surface. Those efficiencies are important, but will not provide quantum leaps in capacity.

Last, some technology programs are designed to "optimize" the aviation system through better planning and improved prediction capability. The gains are marginal in terms of capacity, but significant in terms of delay reduction, since delays increase exponentially as flight operations approach "capacity".

The "ground-up" view encompasses en route airspace. The plan outlines programs designed to increase en route airspace capacity, including Automated En Route Air Traffic Control (AERA), Advanced Traffic Management Systems (ATMS), and others. Major airspace capacity design projects have been accomplished at Boston, Los Angeles, Dallas/Ft. Worth, and were underway at Chicago, Kansas City, Houston/Austin, and New York in 1989. Oakland, Cleveland, and Washington projects began in 1990. Results or progress reports are included in the plan.

From a "ground up" view, having optimized existing airport capacity, terminal airspace procedures and en route airspace capacity using new technology, the next level is "under-utilized airports" and new connecting hub airports for additional aviation system capacity. Beyond that, there is one remaining solution—building new airports. Planning initiatives for new commercial airports are in various stages at Denver, Colorado, Austin, Texas, Atlanta, Georgia, Chicago, Illinois, and other locations.

Aviation's system technology and "optimization" programs hold great promise for new

system capacity during the 1990's. Beyond the year 2000, new airports will be required to maintain the same quality of air service available today.

The federal airport grant program is scheduled for Congressional re-authorization in the early 1990's. Historically, federal airport grants represent between 35 and 40 percent of total capital investment for airports, the remainder coming from local and state sources. Total airport development requirements are in excess of $6 billion per year.

System capacity must continue to grow in order to maintain the same level of air service quality. The majority of cities with air service in 1978 received more frequent service in 1989. Many smaller cities have benefited from the emphasis on hub and spoke airline service in the last decade, receiving more service to connecting hub airports from more than one airline. The expansion of air service networks has increased the number of carriers competing for passengers in a majority of travel markets. In the dozen years since airline deregulation, real air fares have declined. System capacity must continue to grow to allow for airline competition if that trend is to continue.

In conclusion, both the quality and cost of air service is strongly tied to aviation system capacity, and will continue to have favorable trends only if aviation system capacity grows.

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Chapter 1

Introduction

1.1 The Need for Aviation System Capacity Improvement

In 1988, 21 airports each exceeded 20,000 hours of airline flight delays.[1] By 1998, the number of airports which could exceed 20,000 hours of annual aircraft delay is projected to grow from 21 to 41, unless capacity improvements are made. The purpose of this plan is to identify and facilitate actions that can be taken by both the public and private sector to prevent the projected growth in delays. These actions include:

In 1988, 21 airports exceeded 20,000 hours of airline flight delays. By 1998, the number of airports which could exceed 20,000 hours of annual aircraft delay is projected to grow to 41.

- Airport Development
- Airspace Development and New Airspace Procedures
- New Technology, and
- Marketplace Solutions

While current forecasts project serious delays in the absence of capacity improvements, the message shown in the following pages is positive. For example, much is currently being done to improve the situation through new construction and Air Traffic Control (ATC) procedural enhancements. In addition, there are many emerging technologies in the surveillance, communications, and navigation areas that will further improve the efficiency of the existing and new runways.

1. With an average airline operating cost of about $1,600 per hour of delay, this means that each of these 21 airports incurred over $32 million dollars of delay in 1988.

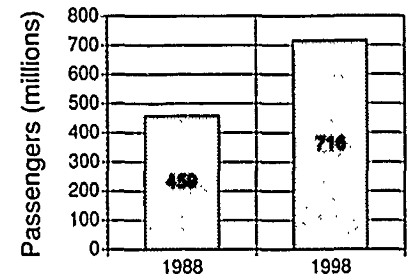
1.2 Level of Aviation Activity

The top 100 airports[2] account for 90 percent of the 459 million airline passengers who enplaned nationally in 1988.

In 1998, 716 million passengers are forecast to enplane at these airports. This represents a projected growth in enplanements of 56 percent over the next 10 years.

The top 100 airports account for 90% of the 459 million airline passengers who enplaned nationally in 1988.

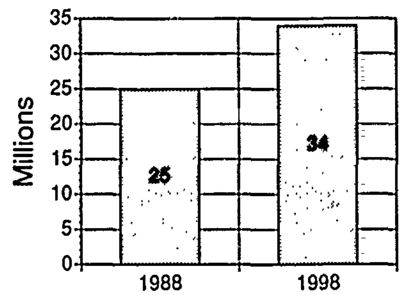
In 1988, approximately 25 million aircraft operations occurred at these top 100 airports. By 1998, operations are forecast to grow to 34 million at the same 100 airports; a projected growth in operations of 36 percent.[4]



Enplanements

1.2.1 Activity Statistics at 100 Selected Airports[5]

Of the top 100 airports, enplanements increased at 50 airports from CY87 to CY88, decreased at 45, and remained essentially the same at 5 airports.[6] Aircraft operations increased from FY88 to FY89 at 36 airports, decreased at 55, and remained essentially the same at 8 of them.[7]



Operations

Aircraft operations increased from FY88 to FY89 at 36 airports, decreased at 55, and remained essentially the same at 8 of them.

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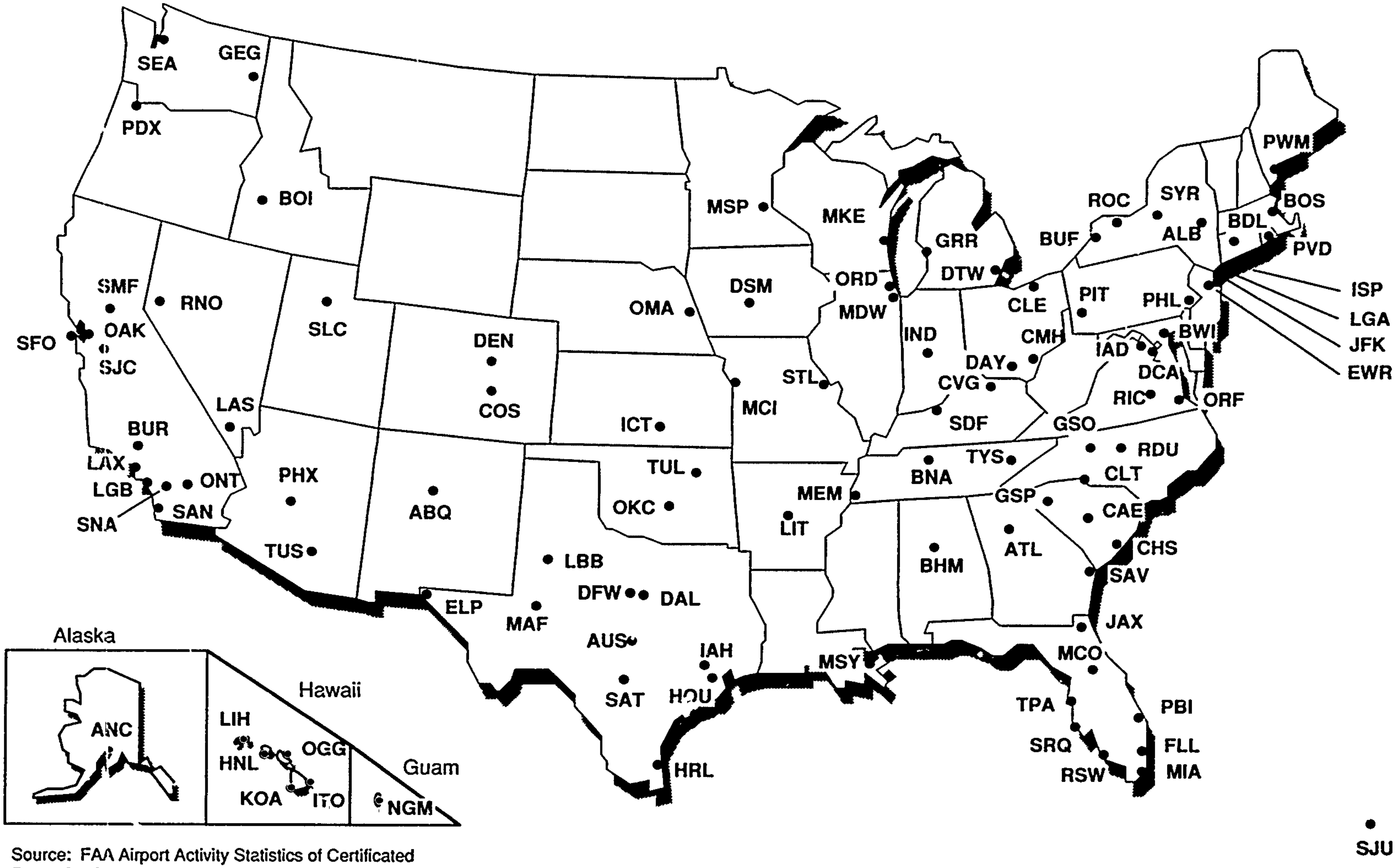
2. The top 100 airports were chosen based on CY88 passenger enplanement data as listed in *Airport Activity Statistics of Certified Route Air Carriers*, 1988 enplanement data. A national map of the 100 airports is pictured in Figure 1-1, and recent operations and enplanement data are provided in Table A-1 of Appendix A.
3. Current enplanement data, a ten year forcast, and percentage growth that the forecast represents are shown in Table A-2 (Appendix A).
4. Table A-3 (Appendix A) shows 1988 aircraft operations, 1998 forcasts, and percent change by airport.
5. The 100 selected airports were chosen based on *Airport Activity Statistics of Certified Route Air Carriers*, 1988 enplanement data. Table A-1 (Appendix A) provides current enplanement and operations data.
6. See Table A-4 (Appendix A) for a ranking by percentage growth in enplanements at the top 100 airports.
7. See Table A-5 (Appendix A)



Source: FAA Airport Activity Statistics of Certificated Route Carriers-1988

Figure 1-1. The Top 100 Airports by 1988 Enplanements.

1.2.2 Traffic Volumes in the 20 Air Route Traffic Control Centers (ARTCCs)

Air Route Traffic Control Center (ARTCC) volume statistics for 1989 showed that Instrument Flight Rule (IFR) operations increased at 14 of the 20 Continental United States Air Route Traffic Control Centers from 1988[8].

In 1988, the number of aircraft flying under instrument rules handled by ARTCCs increased by 1.0 percent from 1987 to 36.1 million operations. As was the case with activity at FAA towered airports, much of the increase at the centers can be attributed to the growth in commercial aviation activity. Commercial aircraft handled at the centers increased by 5.4 percent, compared with a decline of 5.9 percent in noncommercial aircraft handled. The number of commuter aircraft handled increased by 9.4 percent; the number of air carrier aircraft handled increased by 3.9 percent; the number of general aviation aircraft handled declined by 1.2 percent; and the number of military aircraft handled declined by 13.2 percent.

Aircraft operations at the centers are expected to grow by an average of 2.3 percent a year between 1989 and 2000. In absolute numbers, center operations are forecast to increase from 36.1 million aircraft handled in 1988 to 47.8 million in 2000. In 1988, 49.2 percent of the traffic handled at centers were air carrier flights. This proportion is expected to increase only slightly to about 49.8 percent in 2000. In 1988 only 16.0 percent of the traffic handled were commuter operations. By the year 2000 approximately 18.8 percent of the centers' workload is expected to be generated by commuters. The projected annual growth rates by user groups over the forecast period are: air carrier, 2.3 percent; commuter/air taxi, 3.7 percent; and general aviation, 2.2 percent.

Instrument Flight Rule (IFR) operations increased at 14 of the 20 continental U.S. Air Route Traffic Control Centers in 1989 from 1988.

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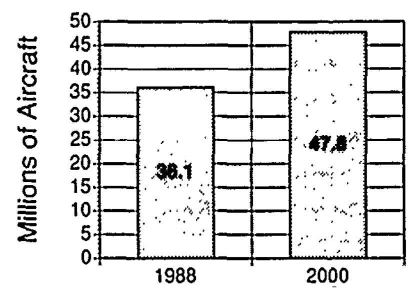
Forecast



ARTCC Operations

8. Figure 1-2 provides a map of the 20 continental United States (CONUS) ARTCCs. Figure 1-3 provides a comparison of the number of operations during FY89 versus the number of operations in FY88 at each of the 20 ARTCCs in CONUS. Figure 1-4 shows FY89 operations, and a 10-year forcast.

Chicago Center, the busiest FAA ARTCC in 1988 handling 2.39 million aircraft, is projected to handle 2.46 million aircraft by the year 2000. Altanta Center is forecast to experience the largest absolute growth, from 2.31 million aircraft operations in 1988 to 3.5 million in the year 2000. This is attributable to the expected increase in airport hubbing activity in the southeastern United States. The projected annual average growth rates of the Los Angeles and Honolulu Centers over the period from 1988 to 2000 are significantly higher (4.3 percent and 4.7 percent, respectively) than the projected national rate of 2.3 percent. These growth rates reflect the increasing importance of the Pacific markets.

The busiest FAA ARTCCs in 1988 were: Chicago, Cleveland, Atlanta, and Washington. Forecasts for 1998 indicate a change in ranking of the busiest Air Traffic Control Centers to: Atlanta, Washington, Los Angeles, and Chicago.

The busiest FAA ARTCCs in 1988 were:
Chicago
Cleveland
Atlanta
Washington

Forecasts for 1998 indicate a change in ranking of the busiest ARTCCs to:
Atlanta
Washington
Los Angeles
Chicago

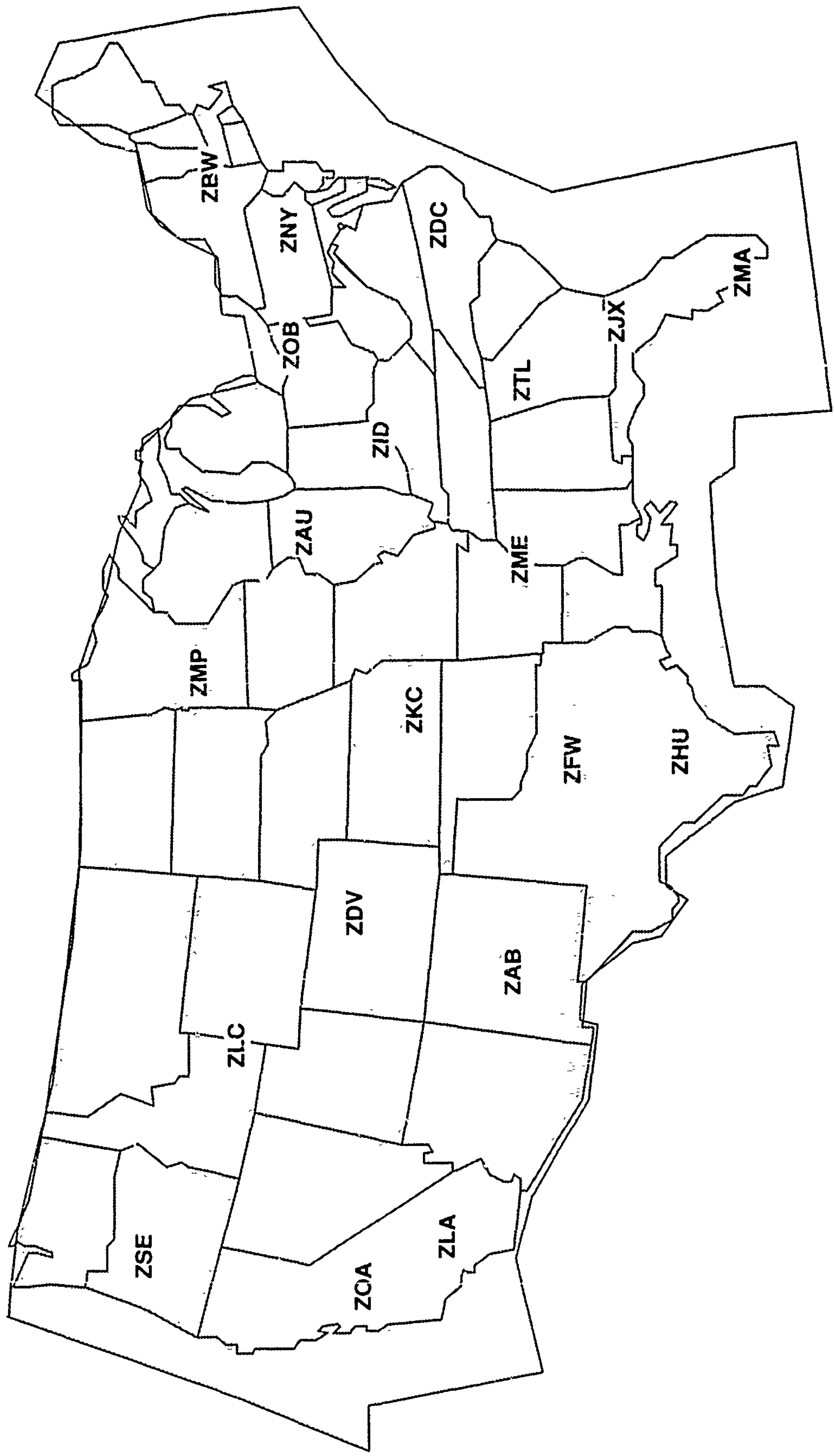


Figure 1-2. The 20 Continental U.S. Air Route Traffic Control Centers

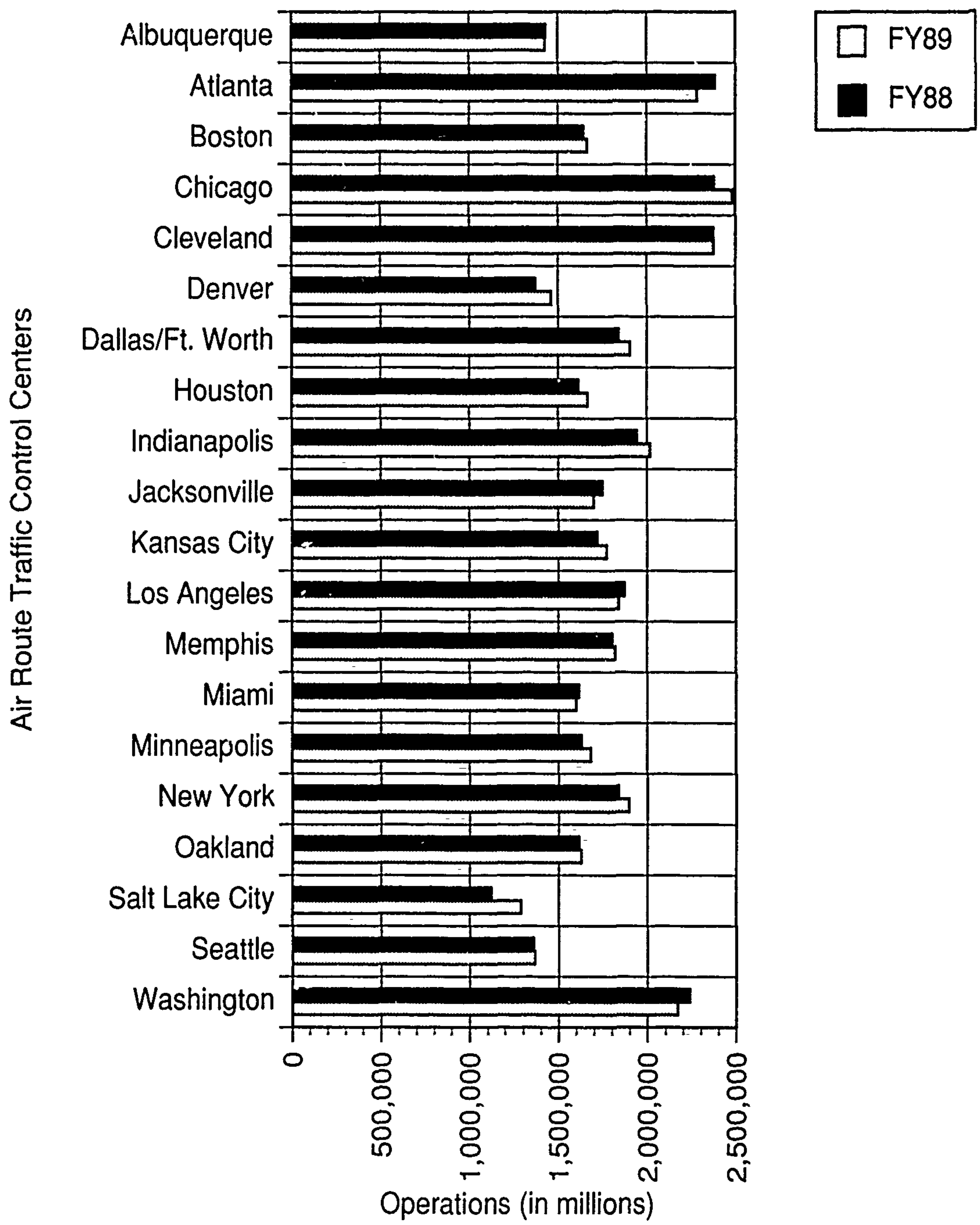


Figure 1-3. Operations at Air Route Traffic Control Centers

(Source: ATO-130 Air Traffic Activity and Delays Report, Sept. 1989)

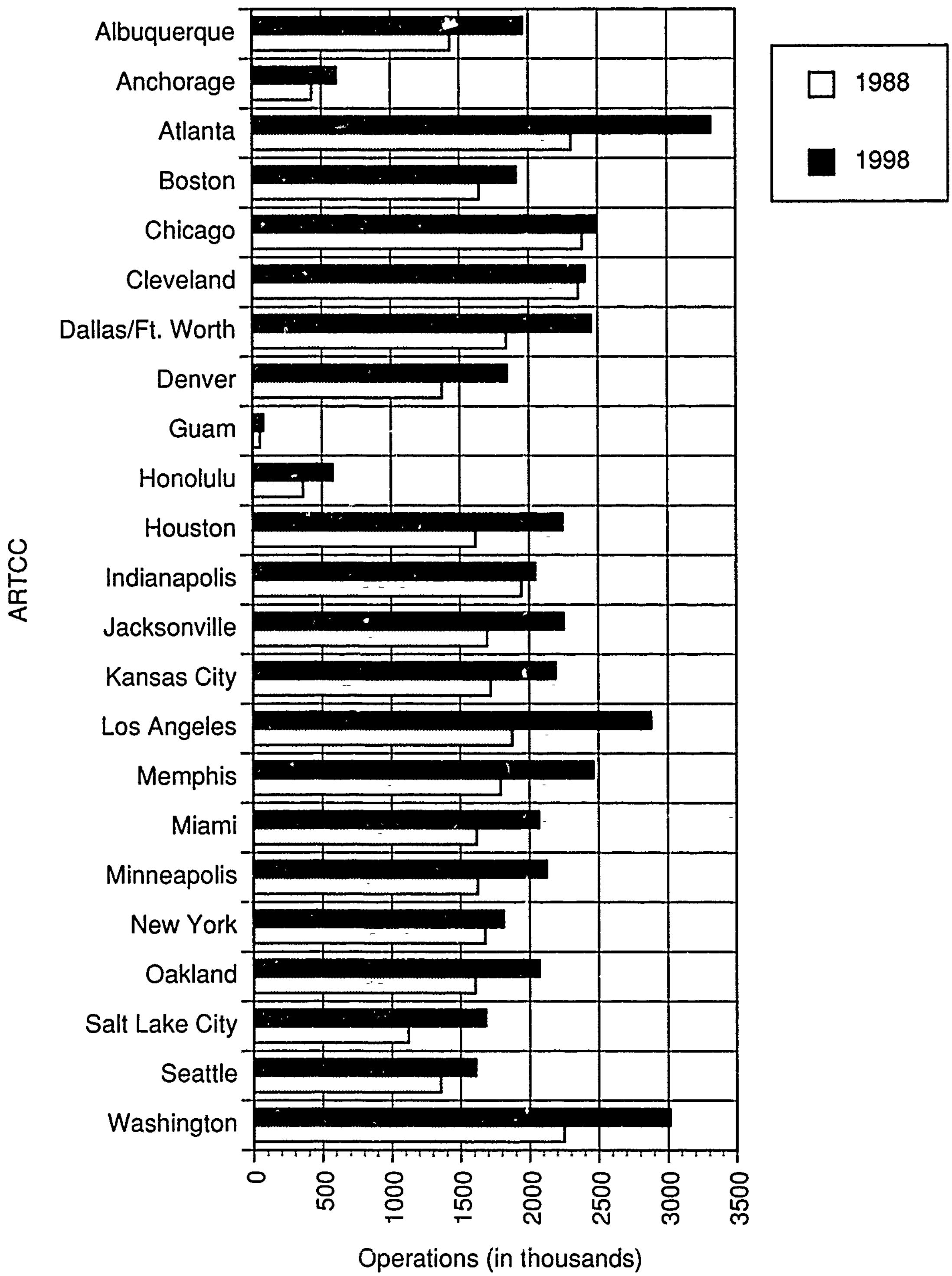


Figure 1-4. Air Route Traffic Control Center Forecasts

(Source: APO ARTCC Forecasts Fiscal Years 1989-2000, April 1989.)

1.3 Delay[9]

1.3.1 Delay by Cause

Weather was attributed as the primary cause of 57% of operations delayed by 15 minutes or more in 1989, down from 70% in 1988.[10] Terminal air traffic volume accounted for a record 29% of delays greater than 15 minutes (up from 9% in 1988), while ai traffic center volume accounted for 8% of delays. Runway construction was the cause of 3% of delay in FY89, NAS equipment interruptions for 2%, and 1% was attributed to other causes.

Although flight delays exceeding 15 minutes were experienced on 391,000 flights in 1989, an increase of 21% over 1988, the total remains below the 1986 and 1984 levels of 418,000 and 404,000, respectively. In FY88, weather and terminai volume accounted for 79% of delays; in FY89, weather and terminal volume accounted for 86% of delays. Terminal volume was the primary cause of delay greater than 15 minutes 29% of the time in FY89, up dramatically from 9% the year before. With the exception of the split between terminal and center volume delays, the basic distribution of delay by cause has remained fairly consistent over the past six years.[11]

Weather was attributed as the primary cause of 57% of operations delayed by 15 minutes or more in 1989, down from 70% in 1988.

Terminal air traffic delays accounted for a record 29% of delays greater than 15 minutes (up from 9% in 1988), while air traffic center volume accounted for 8% of delays.

Although flight delays exceeding 15 minutes were experienced on 391,000 flights in 1989, an increase of 21% over 1988, the total remains below the 1986 and 1984 levels of 418,000 and 404,000, respectively.

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9. Operations and enplanement data from the top 100 airports and the 20 CONUS ARTCCs presented in Section 1.1 are measures of airport and system activity. Delay can be thought of as another system performance parameter; as an indicator that capacity is perhaps being reached and even exceeded. Although no existing delay reporting system is fully comprehensive, this Plan aims to identify problem areas through available data, such as the following delay information, and the previously mentioned aviation activity statistics.

   The Federal Aviation Administration (FAA) maintains two major delay reporting systems, Air Traffic Operations Management System (ATOMS) and Standardized Delay Reporting System (SDRS). ATOMS and SDRS define delay as the difference between actual and optimal flight time, as opposed to passenger delay (the difference between actual and scheduled flight time).

   The delay described in this Plan is actual delay — the difference between actual and optimal flight time (achievable in the absence of adverse weather, congestion, or National Airspace System (NAS) equipment outages, runway closures, etc. . It does not include delay caused by problems in the purview of the airlines, such as aircraft maintenance, crew availability, etc. It is characterized both by the phase of flight in which it is incurred and by cause. Airline schedules can absorb some actual delay, since flight time used in their schedules anticipates some delay.

   Each delay reporting system collects and reports delay in a different way. ATOMS delay data, which includes data that used to be reported under NAPRS (National Airspace Performance Reporting System), is reported by controllers and supervisors at Air Traffic Control (ATC) facilities. The number of operations delayed by 15 minutes or more is recorded, as well as the cause of the delay. SDRS delay data is provided by three major air carriers comprising approximately 25% al all air carrier operations. This system chronicles delay during all four phases of flight and is subdivided into length of delay.

10. See Figure 1-5 for the breakdown of FY88 and FY89 primary causes of delay.

11. See Table 1-1 for the 5 year history of this breakdown of delay by primary cause.

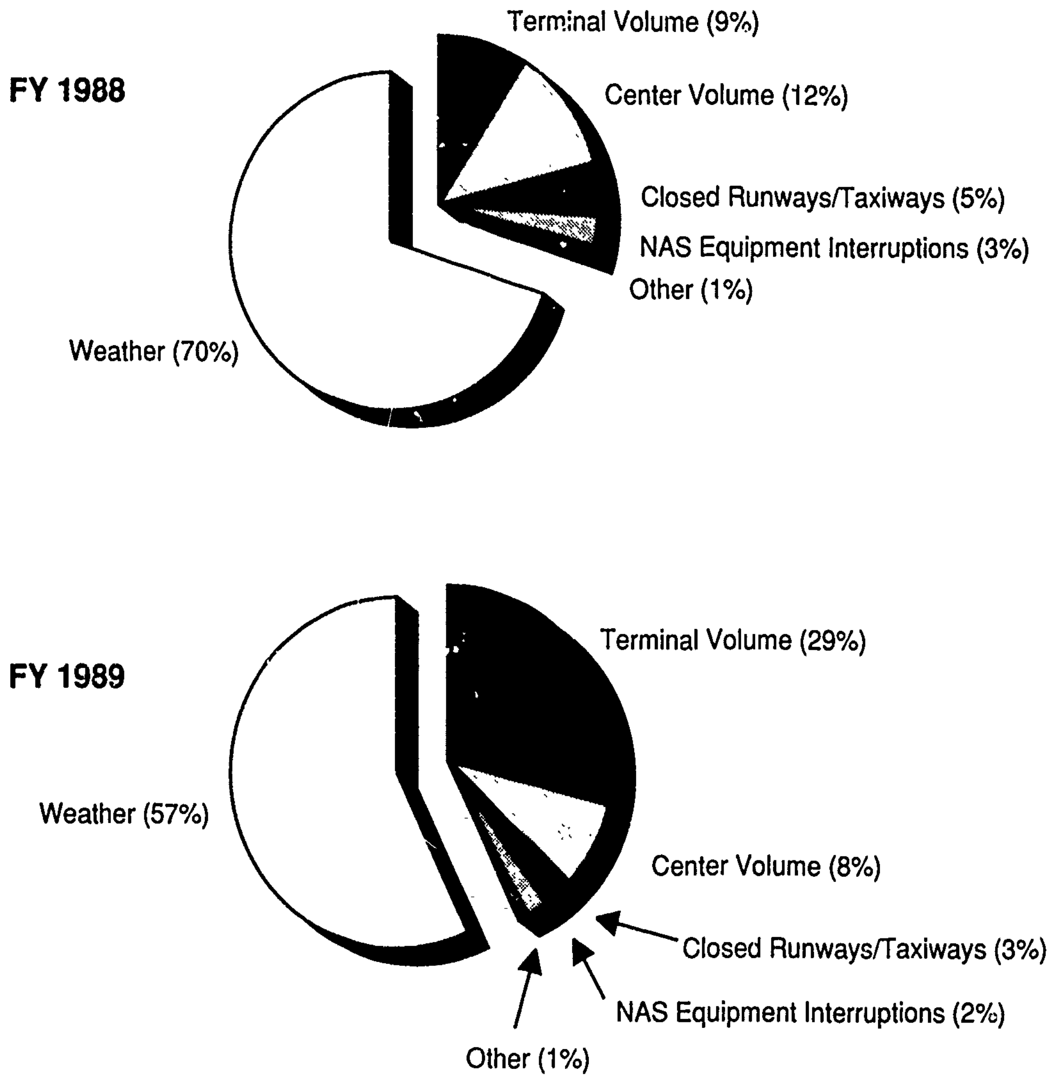


Figure 1-5. Primary Cause of Delay of 15 Minutes or More in FY88 and FY89
Source: ATOMS data

Table 1-1. Distribution of Delay Greater Than 15 Minutes by Cause, 1984-1989

Cause	1984	1985	1986	1987	1988	1989
Weather	60%	68%	67%	67%	70%	57%
Terminal Volume	18%	12%	16%	11%	9%	29%
Center Volume	16%	11%	10%	13%	12%	8%
Closed Runways/Taxiways	3%	6%	3%	4%	5%	3%
NAS Equipment	2%	2%	3%	4%	3%	2%
Other	1%	1%	1%	1%	1%	1%
Total Operations Delayed (000s)	404	334	418	325	322	391
Percent Change from Previous Year		-17%	+25%	-22%	-1%	+21%

1.3.2 Delay by Phase of Flight[12]

Nearly eighty percent of all flights are delayed 1-14 minutes in taxi-in or taxi-out phases of flight. Only 5 percent of flights have any gatehold delay. More delay occurs during the taxi-out phase than any other phase.[13]

Nearly eighty percent of all flights are delayed 1-14 minutes in taxi-in or taxi-out phases of flight.

Taxi-in and taxi-out delay decreased slightly from 1987 to 1988, and airborne delay increased for the first time in five years; while from 1984 to 1987, airborne delay had been declining, while delay on the ground had been increasing.[14]

To put this in perspective, there were 25 million operations in 1988 at the top 100 airports. With an average airborne delay of 4.4 minutes per aircraft, this means that there was a total of over 0.9 million hours of delay, which, at an estimated $1,600 per hour, cost the airlines $1.4 billion.

12. The SRDS delay reporting system accounts for any delay as opposed to major (greater than 15 minutes) delay as measured by the ATOMS system. SRDS defines delay relative to the following four phases of flight:

    Taxi-in Delay: The difference between touchdown time and gate arrival time, minus a standard taxi-in time for a particular type of aircraft and airline at a specific airport.

    Taxi-out Delay: The difference between the time of lift-off and the time that the aircraft departed the gate, minus a standard taxi-out time established for a particular type of aircraft and airline at a specific airport.

    Airborne Delay: The difference between the time of lift-off from the origin airport and touchdown, minus the computer-generated optimum profile flight time for a particular flight, based on atmospheric conditions, aircraft loading, etc.

    Gate-hold Delay: The difference between the time that departure of an aircraft is authorized by ATC and the time that the aircraft would have left the gate area in the absence of an ATC gatehold.

13. Table 1-2 presents the distribution of delay by length of delay and the phase of flight.
14. Table 1-3 shows the overall rise in average total delay throughout the four phases of flight as reported by SRDS.

Table 1-2. Delay by Phase of Flight (%)[15]

Length of Delay (In Minutes)	Gatehold	Taxi-Out	Airborne	Taxi-In
0	96.0%	8.1%	32.0%	21.2%
1-14	2.3%	79.1%	63.1%	77.0%
15-29	0.8%	10.9%	3.3%	1.5%
30-59	0.6%	1.6%	0.9%	0.3%
60+	0.3%	0.3%	0.7%	0.0%
Total	100.0%	100.0%	100.0%	100.0%

Table 1-3. Delay by Phase of Flight, 1984-1988[15]

	Average Delay (in minutes)				
Phase of Flight	**1984**	**1985**	**1986**	**1987**	**1988**
ATC Gatehold	0.7	1.0	1.1	1.0	0.9
Taxi-out	6.5	6.4	7.3	7.9	7.7
Airborne	4.0	4.0	3.7	3.6	4.4
Taxi-in	2.4	2.5	3.0	3.0	2.6

15. Source: SDRS Data for first three quarters of calendar year 1988.

1.3.3 Identification of Forecast Delay-Problem Airports

In FY 1989, the number of airline flight delays in excess of 15 minutes increased compared to 1988 at 12 of 22 major airports.[16] The percentage of flights delayed at these airports ranged from 0.1% of flights at Las Vegas to 10.3% at Newark. The percentages at Newark, O'Hare and LaGuardia nearly doubled since FY88.[17] Three of the five top airports in delays exceeding 15 minutes were in the New York area.

In FY89, the number of airline flight delays in excess of 15 minutes increased compared to FY88 at 12 of 22 major airports. The percentage of flights delayed at these airports ranged from 0.1% of flights at Las Vegas to 10.3% at Newark.

Forecasts suggest that, in the absence of capacity improvements, delay in the system will continue to grow.[18] In 1988, 21 airports each exceeded 20,000 hours of airline flight delays. Assuming no improvements in airport capacity are made, 41 airports are forecast to each exceed 20,000 hours of airline flight delays by 1998.

With no improvements in airport and airspace capacity, four airports are forecast to each exceed 100,000 hours of airline aircraft delays by 1998 as opposed to one airport in 1988.

With no improvements in airport and airspace capacity, four airports are forecast to each exceed 100,000 hours of airline aircraft delays by 1998 as opposed to one airport in 1988.

Likewise, with no capacity improvements, 15 airports are forecast to have 50,000 to 100,000 hours of airline aircraft delays by 1998, as opposed to just five today.

16. Figure 1-6, Delays Per 1,000 Operations.
17. Table 1-4, Percentage of Operations Delayed 15 Minutes or More.
18. Table 1-5, 1988 Actual and 1998 Forecast Air Carrier Delay Hours.

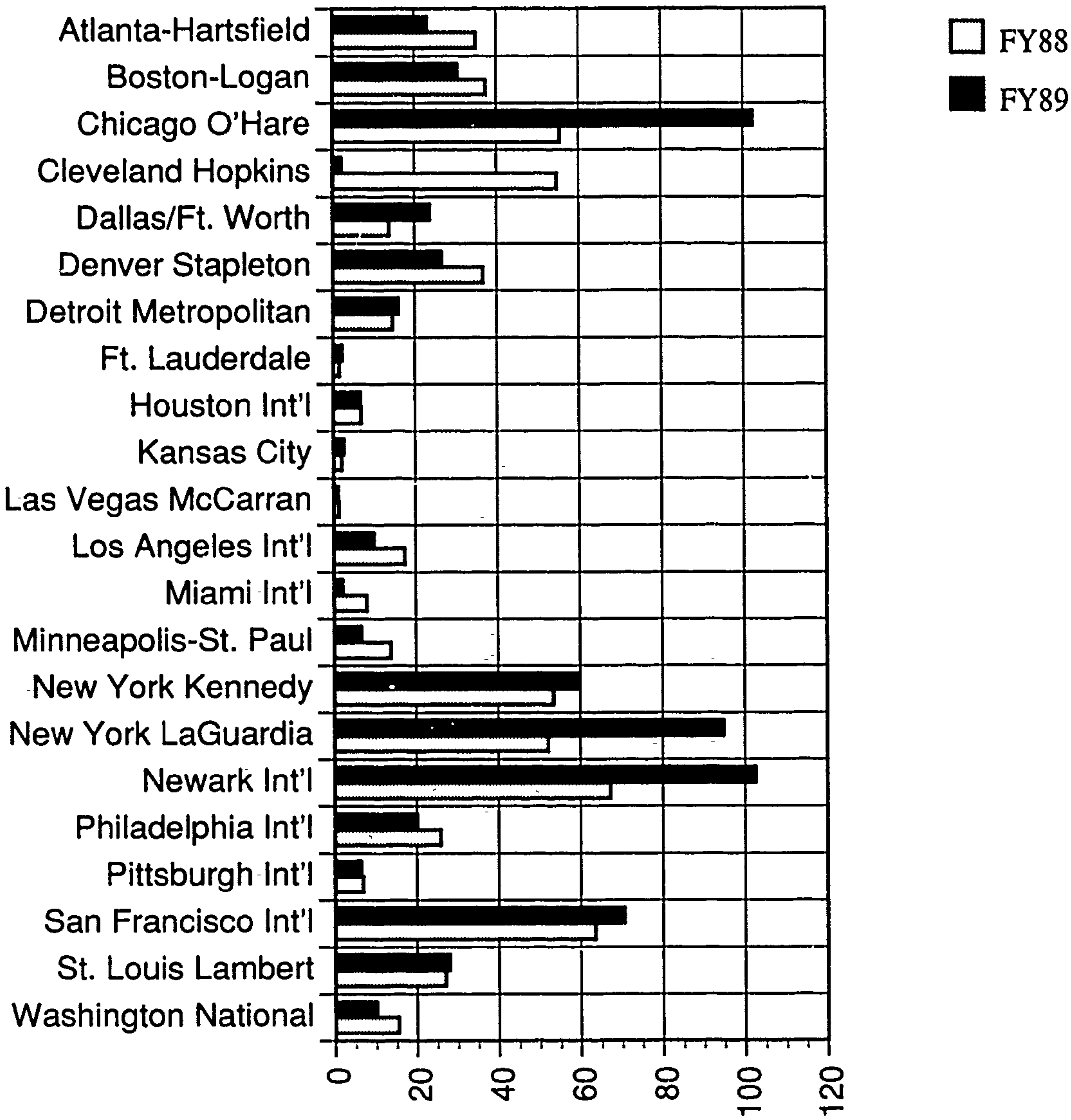


Figure 1-6. Delays Per 1,000 Operations

(Source: ATOMS Data)

Table 1-4. Percentage of Operations Delayed 15 Minutes or More

Airports	Percentage				
	1985	1986	1987	1988	1989
Newark International	9.2	13.8	6.5	6.7	10.3
Chicago O'Hare International	4.1	5.6	4.6	5.5	10.2
New York LaGuardia	9.2	8.9	6.5	5.2	9.4
San Francisco International	3.4	5.3	6.2	6.3	7.0
New York Kennedy	6.1	7.0	6.5	5.3	6.0
Boston Logan International	6.1	7.3	4.8	3.7	3.0
St. Louis-Lambert International	4.6	4.4	1.6	2.7	2.8
Denver Stapleton International	4.6	3.2	3.7	3.7	2.6
Dallas-Fort Worth International	1.7	2.6	2.0	1.4	2.4
Atlanta Hartsfield International	6.2	6.5	6.2	3.5	2.3
Philadelphia International	0.9	2.0	3.7	2.6	2.0
Detroit Metropolitan	2.1	1.3	1.5	1.5	1.6
Los Angeles International	0.8	1.1	3.3	1.7	1.0
Washington National	2.0	3.2	2.3	1.5	1.0
Minneapolis International	2.2	3.9	0.7	1.4	0.7
Houston International	0.3	0.2	0.5	0.7	0.7
Pittsburgh International	1.7	0.6	0.7	0.7	0.6
Cleveland Hopkins International	0.1	0.3	0.1	0.5	0.2
Miami International	0.3	0.7	0.4	0.3	0.2
Kansas City International	0.3	1.0	0.5	0.2	0.2
Fort Lauderdale International	0.1	0.3	0.2	0.2	0.2
Las Vegas McCarran International	0.0	0.0	0.1	0.1	0.1

Source: ATOMS Data

Table 1-5. 1988 Actual and 1998 Forecast Air Carrier Delay Hours

Annual Aircraft Delay	1988		1998	
Greater than 100,000 hours	Chicago O'Hare	ORD	Chicago	ORD
			Dallas-Fort Worth	DFW
			Atlanta	ATL
			Denver	DEN
50,000 to 99,999 hours	Atlanta Hartsfield	ATL	Washington	IAD
	Dallas-Fort Worth	DFW	Newark	EWR
	Los Angeles	LAX	St Louis	STL
	Newark	EWR	Los Angeles	LAX
	Denver	DEN	Phoenix	PHX
			New York	JFK
			San Francisco	SFO
			Covington/Cincinnati	CVG
			Philadelphia	PHL
			Boston	BOS
			Pittsburgh	PIT
			New York	LGA
			Las Vegas McCarran	LAS
			Orlando International	MCO
			Raleigh-Durham	RDU
20,000 to 49,999 hours	New York	LGA	Minneapolis	MSP
	San Francisco	SFO	Salt Lake City	SLC
	New York	JFK	Miami	MIA
	Boston	BOS	Detroit	DTW
	St Louis	STL	Nashville	BNA
	Phoenix	PHX	Washington	DCA
	Miami	MIA	Kansas City	MCI
	Philadelphia	PHL	Charlotte	CLT
	Washington	DCA	Honolulu	HNL
	Pittsburgh	PIT	Houston	IAH
	Detroit	DTW	Windsor Locks	BDL
	Orlando	MCO	Memphis	MEM
	Minneapolis	MSP	Baltimore	BWI
	Charlotte	CLT	Columbus	CMH
	Washington	IAD	Ontario	ONT
			Ft. Lauderdale	FLL
			San Jose	SJC
			Indianapolis	IND
			Seattle	SEA
			Dayton	DAY
			Houston	HOU
			San Diego	SAN

Source: FAA Office of Policy and Plans

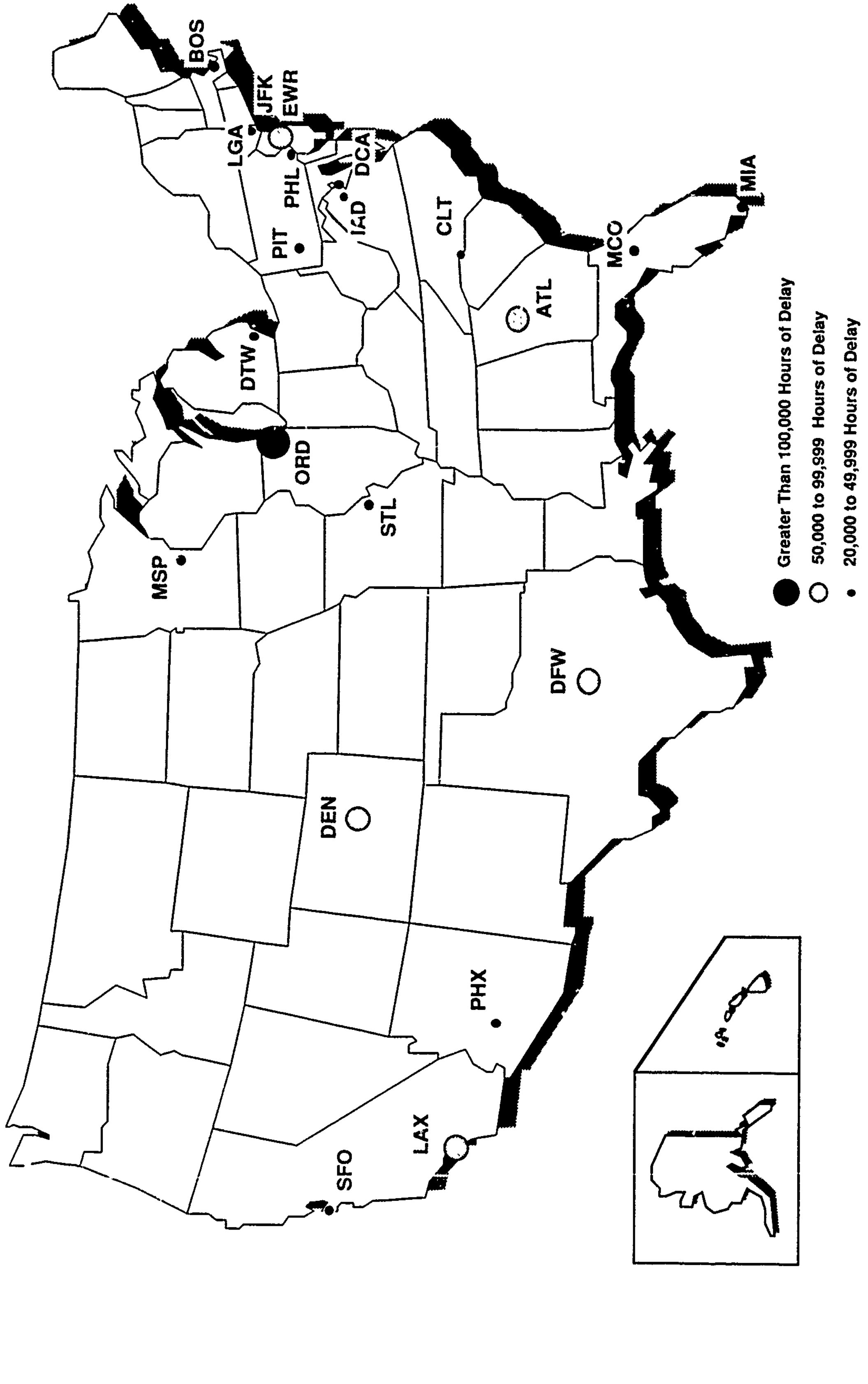


Figure 1-7. Airports Exceeding 20,000 Hours of Annual Aircraft Delay in 1988.
(Source: FAA Office of Policy and Plans)

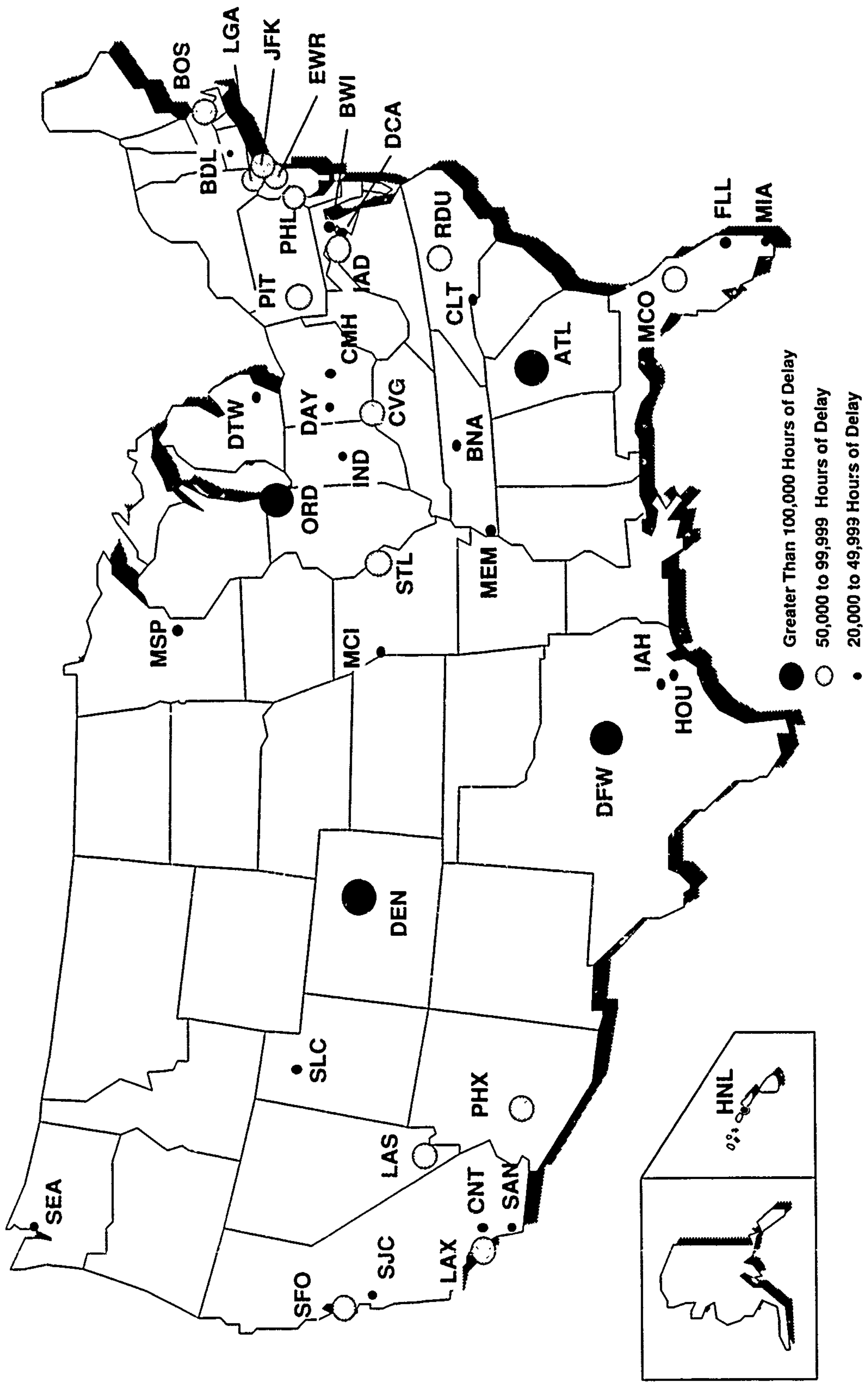


Figure 1-8. Airports Exceeding 20,000 Hours of Annual Aircraft Delay in 1998, Assuming No Capacity Improvements.
(Source: FAA Office of Policy and Plans)

Chapter 2

Airport Development

2.1 Airport Capacity Design Teams

The FAA is co-sponsoring airport capacity design teams at major airports across the U.S. Airport operators, airlines, and other aviation industry representatives work together with FAA representatives to analyze the capacity problem at each individual airport. Capacity-enhancing strategies and related projects are developed. Twenty-four such Design Teams have been brought together and are at various stages in the process.[1]

Table 2-1. Airport Capacity Design Teams.

Completed	Ongoing
Atlanta	Boston
Detroit	Chicago
Memphis	Kansas City
Miami	Nashville
Oakland	Orlando
Phoenix	Raleigh-Durham
San Francisco	Salt Lake City
San Jose	Seattle
St. Louis	Washington-Dulles
	Pittsburgh
	Los Angeles
	Cincinnati
	Philadelphia
	Charlotte
	San Juan

The Airport Capacity Design Teams have developed more than 400 airport capacity projects. New runways are being considered at more than a half dozen major airports as a direct result of Design Team efforts.

The status of these projects are given in Appendix B.

1. Figure 2-1, Airport Capacity Design Teams, and Figure 2-2, Airport Capacity Design Team: Three-Year Plan.

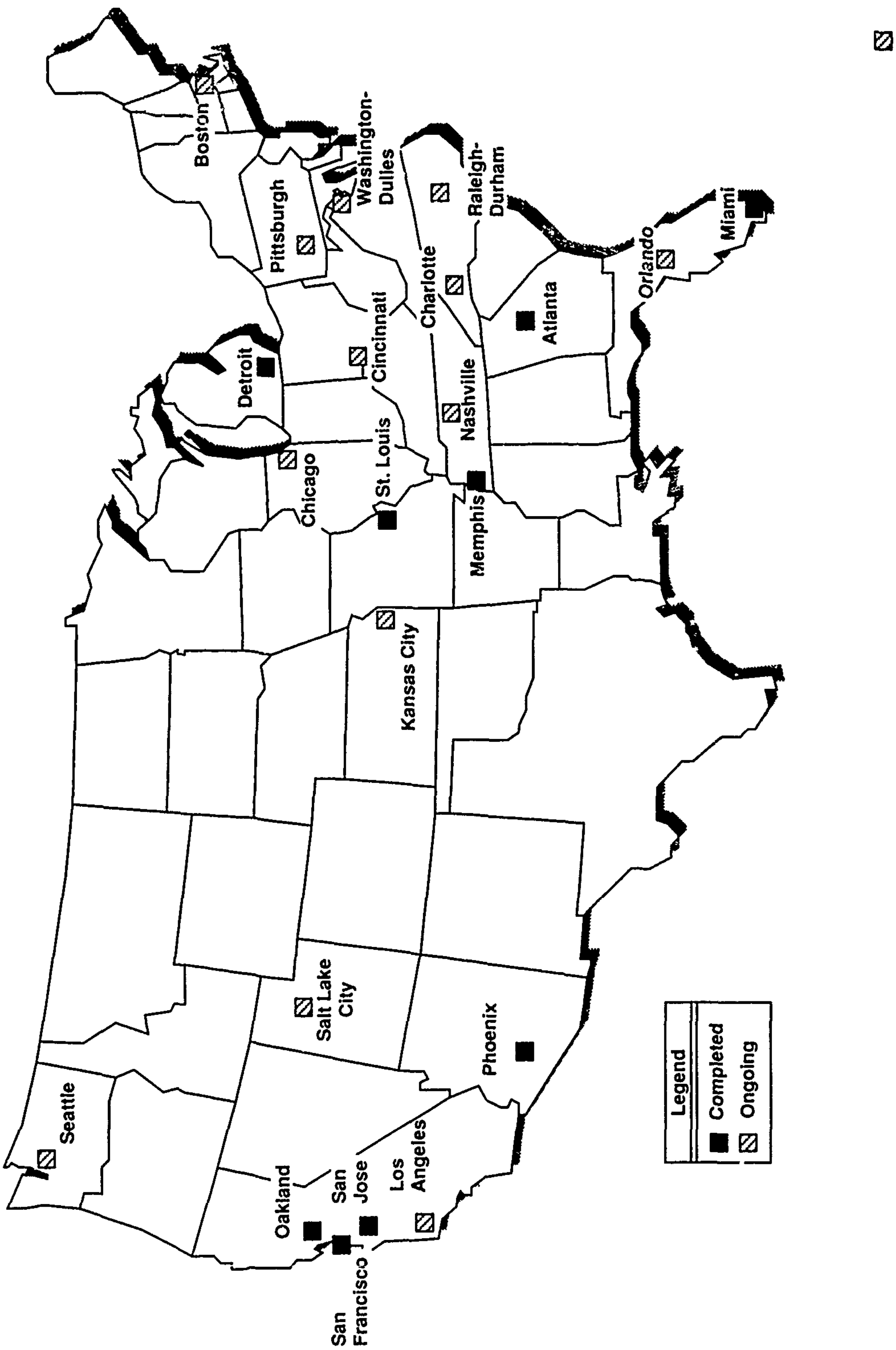
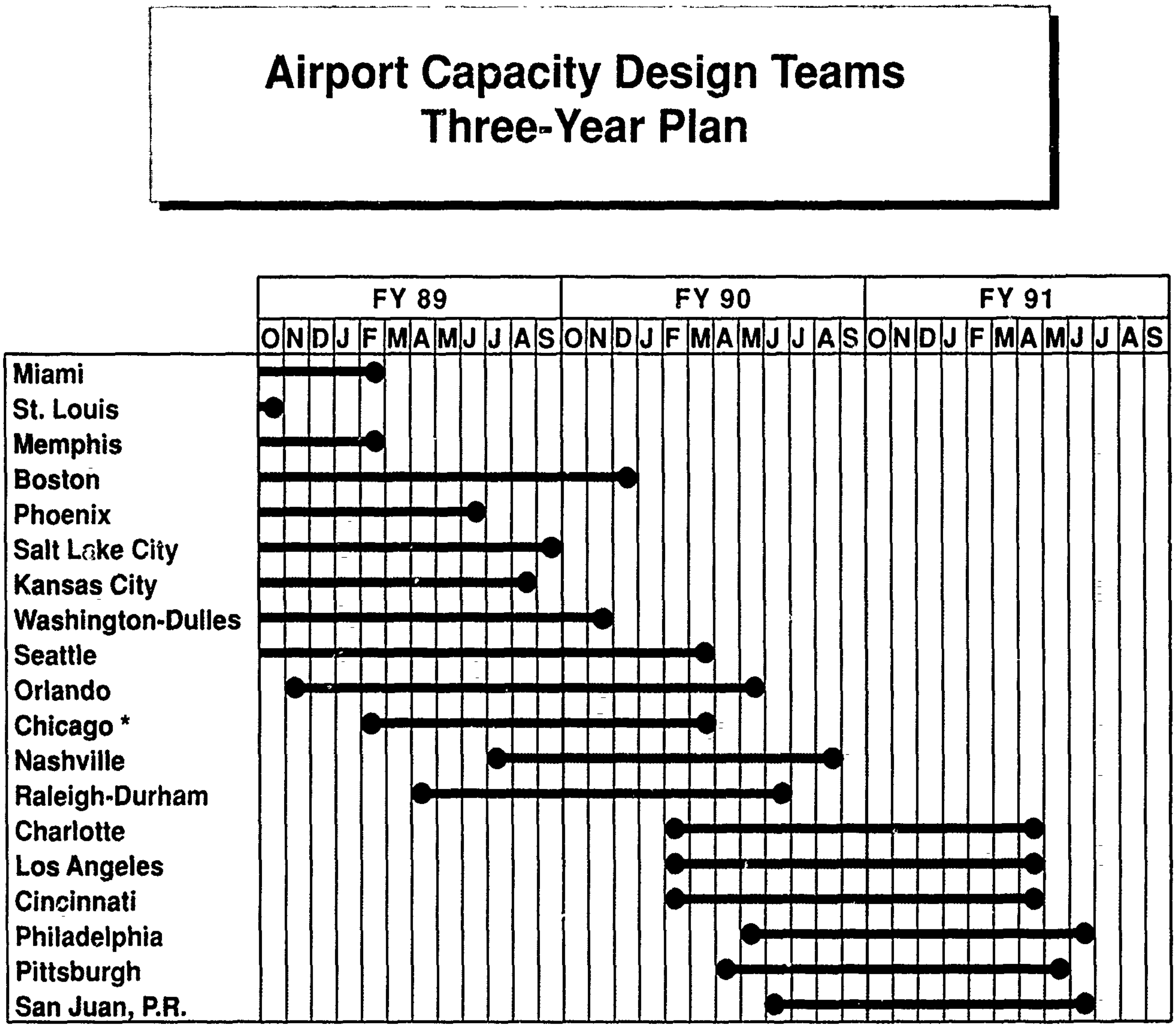


Figure 2-1. Airport Capacity Design Teams.



System Capacity Office — June 1990

* Co-Sponsored

Figure 2-2. Airport Capacity Design Team Three-Year Plan.

2.2 New Construction — New Airports, New and Extended Runways

The construction of new airports, as well as new runways and extensions of existing runways, are the most direct and significant actions that can be taken to improve airport capacity. Large capacity increases, both under VFR and IFR conditions, come from the addition of new runways that are properly placed to allow additional independent arrival and/or departure streams. The resulting increase in capacity is from 33 to 100 percent (depending on whether the baseline is a single, dual, or triple runway configuration.)

Sixty-six of the top 100 airports have proposed new runways or runway extensions to increase airport capacity.

Sixty-six of the top 100 airports have proposed new runways or runway extensions to increase airport capacity.[2]

Seventeen of the 21 airports exceeding 20,000 hours of air carrier flight delay in 1988 are planning new runways or extensions of existing runways.

Seventeen of the 21 airports exceeding 20,000 hours of air carrier flight delay in 1988[3] are in the process of constructing or planning the construction of new runways or extensions of existing runways.

Of the 41 airports that are forecast to exceed 20,000 hours of annual air carrier delay in 1998, if no further improvements are made, 32 propose to build new runways or runway extensions.[4]

The total anticipated cost of completing these new runways and runway extensions exceeds $6 billion. The proposed projects are in various stages of development. Of the documented projects, 73 are shown on an approved airport layout plan (ALP), 21 are known to have completed an environmental impact statement (EIS), 14 are known to have completed an application for an airport improvement program (AIP) grant, and 15 have already begun construction.[5]

New parallel runways were put into service at Nashville, Orlando, and San Jose in 1989. Runway extensions at Fort Lauderdale and Dayton also became operational in 1989. It is anticipated that by the end of 1990, seven more new construction projects will have become operational.

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2. The airports having runway projects are pictured in Figure 2-3 and summarized in Table 2-2 with the projected IFR capacity benefit, the estimated project cost (to the nearest million), and an estimated operational date. Although the single figure of IFR capacity benefit does not reflect all the many significant capacity benefits resulting from this new construction, it is provided as a common benchmark. More detailed descriptions of these projects are included in Appendix C.
3. 20,000 hours of flight delay translates into over $32 million per year at the cost of $1600 per hour of airport delay.
4. As reflected in Figure 2-2.
5. As reflected in Appendix C, Table C-1.

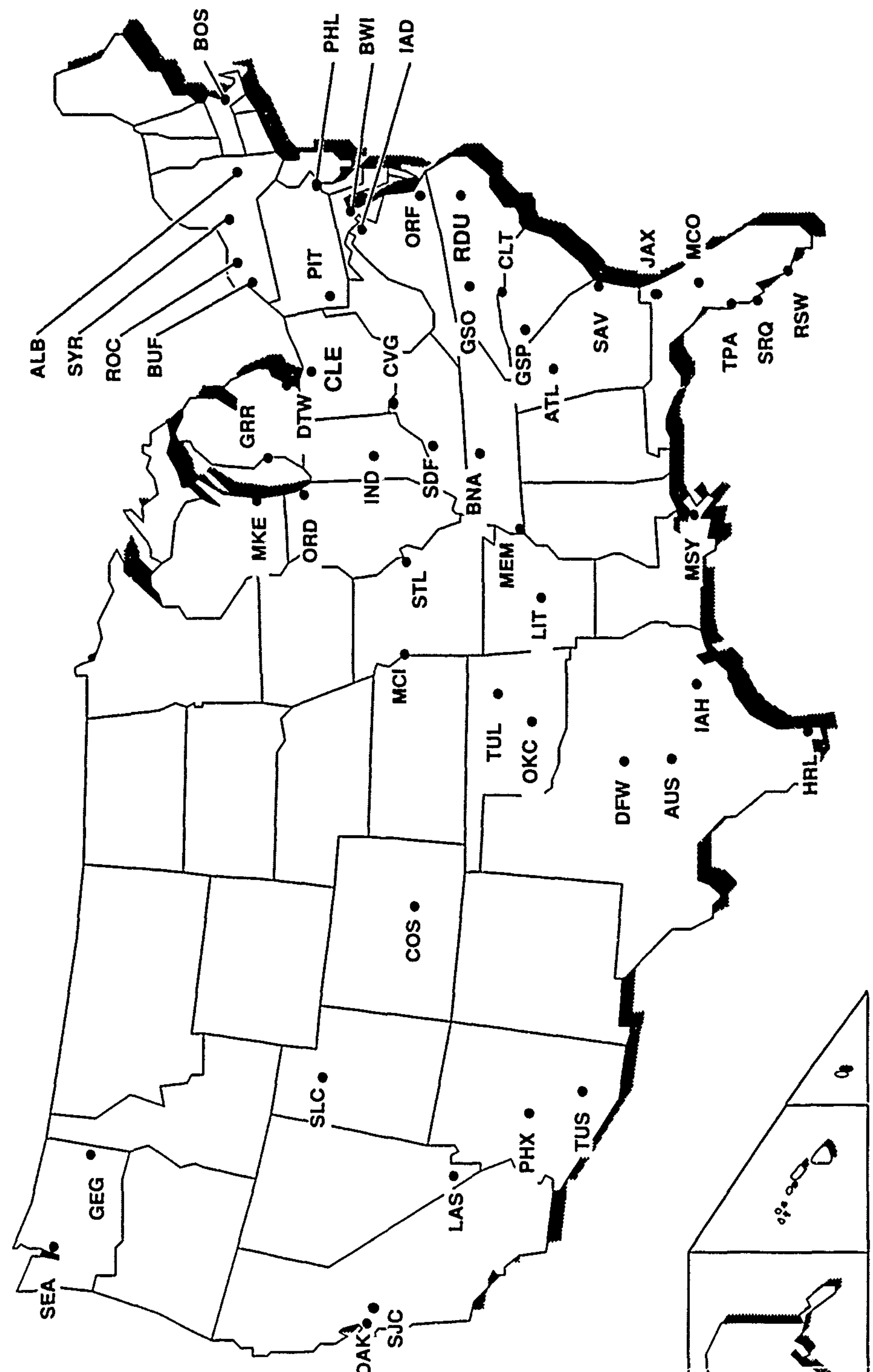

Figure 2-3. New Runways Planned or Proposed Among the Top 100 Airports.

Table 2-2. New and Extended Runways Planned or Proposed+

Airport	Runway	IFR Capacity (ARR/HR)† New Config.	IFR Capacity (ARR/HR)† Current Best	Est. Cost ($M)	Est. Date Oper.
Albuquerque (ABQ)	3/21 extension	26^2	26^2	$11	1990
Albany (ALB)	10/28 extension	26^2	26^2	$2	1997
Albany (ALB)	1R/19L parallel	++	26^2	$15	2007
Atlanta (ATL)	E/W parallel	63^6	52^1	$130	1994
Austin New Airport (AUS)	Parallels — 17/35	52^1	26^2	$550*	1995
Baltimore (BWI)	10R/28L	36^4	26^2	$38	1996
Baltimore (BWI)	15L/33R extension	26^2	26^2	$11	1990
Birmingham (BHM)	18/36 extension	26^2	26^2	$43	1995
Boston (BOS)	14/32	++	26^2		
Boston (BOS)	15L extension	26^2	26^2		
Buffalo (BUF)	5L/23R	$26^{2,8}$	$26^{2,8}$		1999
Buffalo (BUF)	14/32 extension	$26^{2,8}$	$26^{2,8}$	$4	1992
Charlotte (CLT)	18L/36R extension	$52^{7,8}$	$26^{2,8}$	$7	1992
Charlotte (CLT)	18/36 parallel	$78^{3,10}$	$26^{2,8}$	$27	1998
Chicago Midway (MDW)	22L extension	26^2	26^2		
Chicago O'Hare (ORD)	9/27	++	52^1		
Chicago O'Hare (ORD)	14/32	++	52^1		
Cincinnati (CVG)	18L/36R	52^1	26^2	$97	1990
Cleveland (CLE)	reconstruct 5R/23L	26^2	26^2	$17	1990
Colorado Springs (COS)	17L/35R	52^1	26^2	$38	1992
Columbia (CAE)	5/23 extension	26^2	26^2	$15	1990
Columbus (CMH)	10L extension	36^4	36^4	$8	1993
Columbus (CMH)	28R extension	36^4	36^4	$3	1994
Dallas-Fort Worth (DFW)	17R/35L extension	52^1	52^1	$24	1991
Dallas-Fort Worth (DFW)	18L/36R extension	52^1	52^1	$24	1992

\+ Endnotes 1-10, on page 2-10, describe the IFR arrival capacity of the current and potential new configurations.

++ Information on runway location is unavailable or too tentative to determine IFR multiple approach benefit of this new construction project.

* Cost for New Airport (Phase I) land, terminal, runways, etc.

Table 2-2. New and Extended Runways Planned or Proposed (continued)+

		IFR Capacity (ARR/HR)†		Est.	Est.
Airport	Runway	New Config.	Current Best	Cost ($M)	Date Oper.
Dallas-Fort Worth (DFW)	16L/34R	78[3]	52[1]	$100	1993
Dallas-Fort Worth (DFW)	16R/34L	78[3,10]	52[1]	$95	1996
Denver New (DVX)	New Airport	78[3,10]	52[1]	$2,500*	1993
Detroit (DTW)	9R/27L	52[1]	52[1]	$69	1991
Detroit (DTW)	4/22 parallel	63[6]	52[1]	$58	1995
Detroit (DTW)	3L/21R extension	52[1]	52[1]	$7	1990
Fort Lauderdale (FLL)	9R/27L extension	36[4]	26[2]	$26	1995
Fort Myers (RSW)	6/24 extension	26[2]	26[2]	$10	1992
Fort Myers (RSW)	6L/24R parallel	52[1]	26[2]	$47	1994
Grand Rapids (GRR)	8L/26R parallel	52[1]	26[2]	$25	1993
Grand Rapids (GRR)	18/36 extension	26[2]	26[2]	$30	1995
Greensboro (GSO)	5/23 parallel	52[1]	26[2]	$20	2010
Greensboro (GSO)	14/32 extension	26[2]	26[2]	$14	1998
Greer (GSP)	3/21 parallel	52[1]	26[2]	$25	1995
Harlingen (HRL)	13L/31R	26[2]	26[2]	$5	1995
Harlingen (HRL)	13/31 extension	26[2]	26[2]	$7	1995
Houston (IAH)	8L/26R	78[3]	52[1]	$44	1999
Houston (IAH)	9R/27L	52[1]	52[1]	$44	2002
Houston (IAH)	14R/32L extension	52[1]	52[1]	$8	1997
Indianapolis (IND)	5R/23L	36[4]	26[2]	$45	1990
Indianapolis (IND)	5L/23R replacement	26[2]	26[2]	$42	1995
Islip (ISP)	6/24 extension	26[2]	26[2]		
Jacksonville (JAX)	7R/25L parallel	52[1]	26[2]	$37	

\+ Endnotes 1-10, on page 2-10, describe the IFR arrival capacity of the current and potential new configurations.

++ Information on runway location is unavailable or too tentative to determine IFR multiple approach benefit of this new construction project.

* Cost for new airport Phase I.

Table 2-2. New and Extended Runways Planned or Proposed (continued)[+]

Airport	Runway	IFR Capacity (ARR/HR)† New Config.	Current Best	Est. Cost ($M)	Est. Date Oper.
Kansas City (MCI)	1R/19L	52[1]	26[2]	$46	1992
Kansas City (MCI)	9R/27L	26[2]	26[2]	$60	1999
Kansas City (MCI)	18L/36R	52[1]	26[2]	$65	1999
Kansas City (MCI)	18R/36L	78[3]	26[2]	$90	1999
Knoxville (TYS)	5R/23L extension	26[2]	26[2]	$17	1992
Las Vegas (LAS)	7R/25L	26[2]	26[2]	$42	1991
Little Rock (LIT)	4R/22L	52[1]	26[2]	$80	1991
Los Angeles (LAX)	6L/24R extension	52[1]	52[1]	$4	1991
Louisville (SDF)	East parallel	52[1]	26[2]	$250*	1992
Louisville (SDF)	West parallel	52[1]	26[2]		1995
Lubbock (LBB)	8/26 extension	26[2]	26[2]	$6	1995
Memphis (MEM)	18L/36R parallel	52[1]	36[4]	$105	1994
Midland (MAF)	10/28 extension	26[2]	26[2]	$6	1992
Milwaukee (MKE)	7L/25R	36[4]	26[2]		
Milwaukee (MKE)	1L/19R extension	26[2]	26[2]	$13	1992
Minneapolis (MSP)	4/22 extension	36[4]	36[4]	$11	1991
Nashville (BNA)	2C/20C extension	52[1]	52[1]	$40	1991
New Orleans (MSY)	1/19 parallel	52[1]	26[2]	$160	2000
New Orleans (MSY)	10/28 parallel	52[1]	26[2]	$40	1995
New Orleans (MSY)	10/28 extension	26[2]	26[2]	$10	1991
New York Kennedy (JFK)	4L/22R extension	36[4]	36[4]		
Newark (EWR)	11/29 extension	26[2]	26[2]		

\+ Endnotes 1-10, on page 2-10, describe the IFR arrival capacity of the current and potential new configurations.

++ Information on runway location is unavailable or too tentative to determine IFR multiple approach benefit of this new construction project.

* Cost of two new runways together.

Table 2-2. New and Extended Runways Planned or Proposed (continued)+

Airport	Runway	IFR Capacity (ARR/HR)† New Config.	IFR Capacity (ARR/HR)† Current Best	Est. Cost ($M)	Est. Date Oper.
Norfolk (ORF)	5R/23L	26[2]	26[2]	$13	1994
Norfolk (ORF)	14/32 extension	26[2]	26[2]	$2	1996
Oakland (OAK)	11R/29L	++	26[2]	$143	
Oklahoma City (OKC)	17L/35R extension	52[1]	52[1]	$24	2001
Oklahoma City (OKC)	17R/35L extension	52[1]	52[1]	$20	2001
Oklahoma City (OKC)	17/35 parallel	52[1]	52[1]	$55	2001
Orlando (MCO)	17L/35R 4th parallel	78[3]	26[2]	$80	1993
Philadelphia (PHL)	8/26 parallel-commuter		52[1]	52[7]	$100
Philadelphia (PHL)	relocate 9L/27R	52[1]	52[7]		
Phoenix (PHX)	8S/26S 3rd parallel	52[1]	52[1]	$88	1994
Pittsburgh (PIT)	14R/32L parallel	52[1]	52[1]		1995
Pittsburgh (PIT)	4th parallel 10/28	78[3]	52[1]		1995
Raleigh-Durham (RDU)	relocate 5R/23L	52[1]	36[4]	$45	1996
Rochester (ROC)	4R/22L parallel	++	26[2]	$5	1996
Rochester (ROC)	4/22 extension	26[2]	26[2]	$1	1996
Rochester (ROC)	10/28 extension	26[2]	26[2]	$2	1994
Salt Lake City (SLC)	16/34 west parallel	63[6]	36[4]	$95	1994
San Jose (SJC)	30R/12L extension	26[2]	26[2]	$10	1990
Sarasota-Bradenton (SRQ)	14L/32R parallel	26[2]	26[2]		
Savannah (SAV)	9L/27R parallel	52[1]	26[2]	$20	2010
Savannah (SAV)	18/36 extension	26[2]	26[2]	$4	1995
Seattle (SEA)	16/34 west parallel	26[2]	26[2]		
Seattle (SEA)	13/31	26[2]	26[2]		

\+ Endnotes 1-10, on page 2-10, describe the IFR arrival capacity of the current and potential new configurations.

++ Information on runway location is unavailable or too tentative to determine IFR multiple approach benefit of this new construction project.

Table 2-2. New and Extended Runways Planned or Proposed (concluded)+

Airport	Runway	IFR Capacity (ARR/HR)† New Config.	Current Best	Est. Cost ($M)*	Est. Date Oper.
Spokane (GEG)	3L/21R	52[1]	26[2]	$11	1996
St. Louis (STL)	13/31	26[2]	26[2]	$1	
Syracuse (SYR)	10L/28R	52[1]	26[2]	$5	1997
Tampa (TPA)	18R/36L 3rd parallel	52[1]	52[1]	$53	1997
Tucson (TUS)	11R/29L parallel	26[2]	26[2]	$143	1995
Tulsa (TUL)	17/35 parallel	78[3]	52[1]	$100	1998
Washington (IAD)	1W/19W parallel	78[3]	52[1]		1998
Washington (IAD)	12/30 parallel	52[1]	52[1]		1994
Washington (IAD)	12/30 extension	52[1]	52[1]	$7	1992
West Palm Beach (PBI)	9L/27R extension	26[2]	26[2]	$4	1994

Total Estimated Costs of Construction: $6.4 Billion*

+ Endnotes 1-10, below, describe the IFR arrival capacity of the current and potential new configurations.

++ Information on runway location is unavailable or too tentative to determine IFR multiple approach benefit of this new construction project.

* Includes the total costs of the New Austin airport and the New Denver airport, $550 million and $2,500 million, respectively.

† Estimates of generalized hourly IFR arrival capacity increases are included in Table 2-2. Based on a 1987 report, the IFR arrival capacity of any single runway that can be operated independently is 26 arrivals/hour; a dependent parallel pair, 36 arrivals/hour, and independent parallels, 52 (twice that of a single runway) arrivals/hour. Other configurations are multiples of the above. These values are provided to illustrate the approximate magnitude of the capacity increase provided. They should not be taken as the exact capacity of a particular airport since site-specific conditions (e.g., varying fleet mixes) can result in differences from these estimates.

Endnotes:

1. Independent parallel approaches [52 IFR arrivals per hour].
2. Single runway approaches [26 IFR arrivals per hour].
3. Triple approaches (currently not authorized) [78 IFR arrivals per hour].
4. Dependent parallel approaches [36 IFR arrivals per hour].
5. Triple approaches with parallel and converging pairs may permit more than 52 IFR arrivals if procedures are developed.
6. Triple parallel approaches with dependent and independent pairs (currently not authorized) [63 IFR arrivals per hour].
7. Converging IFR approaches to minima higher than CAT I ILS [52 IFR operations per hour].
8. Added capacity during noise abatement operations.
9. Independent parallel approaches with one short runway.
10. If independent quadruple approaches are approved [104 IFR arrivals per hour].

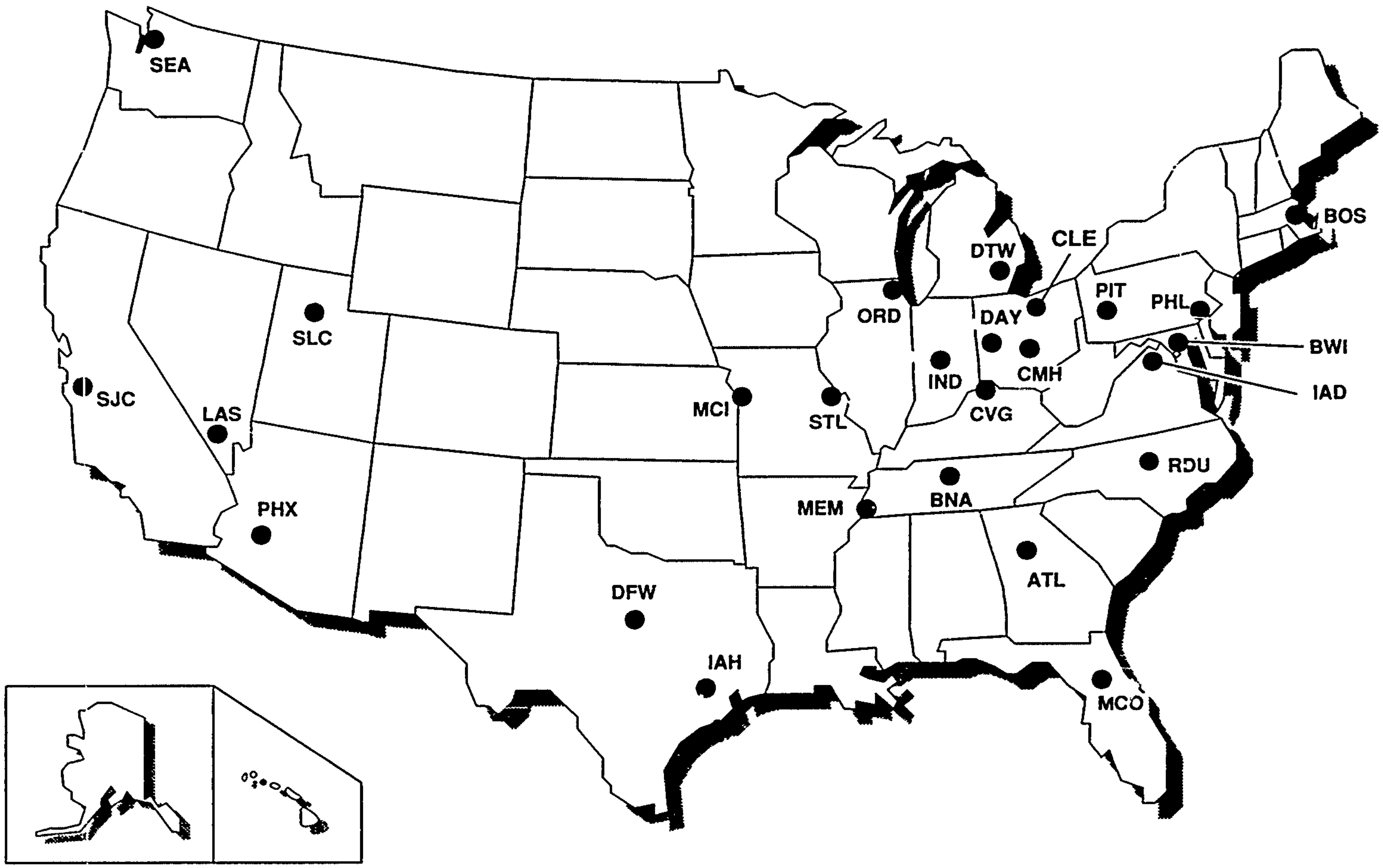

Figure 2-4. Proposed New Runways
(Planned or Proposed Among Airports Forecast to Exceed 20,000 Hours of Annual Aircraft Delay in 1998.)

Chapter 3

Airport and Airspace Capacity

3.1 Approach Procedure Improvements

In FY89, 57% of all delays were attributed to adverse weather conditions.

In FY89, 57% of all delays were attributed to adverse weather conditions. These delays are in part the result of instrument approach procedures that are much more restrictive than the visual procedures in effect during better weather conditions (IFR instead of VFR procedures). Much delay could be eliminated if the approach procedures used during IFR operations matched those observed during VFR operations.[1]

During the past few years the aviation industry has been working on the development of new, capacity-enhancing approach procedures for use during IFR. In most cases, these are multiple approach procedures aimed at allowing the simultaneous, or near-simultaneous, use of more than one arrival runway. The following sections present a brief description of the most promising new ATC procedures, their estimated benefits, supporting technology, and those candidate sites that might benefit through use of the new procedures. Some airports can potentially operate more than one new procedure.[2]

1. In general, depending on the airport aircraft mix, single-runway IFR approach procedures allow about 26 arrivals per hour. Hence, two simultaneous approach streams, when operating independently of each other, increase arrival capacity to 52 per hour. Three streams would allow 72 hourly arrivals, and so on. Such procedures are called "independent," because the aircraft in one stream do not interfere with arrivals in the other. "Dependent" procedures place restrictions between the two runways, resulting in an arrival capacity of 26 to 42 arrivals per hour. In the case of triple streams, the number of arrivals are somewhere between 52 and 78, depending on airport runway configurations.
2. The candidate sites have been chosen by inspecting runway configurations and proposed plans only. Considerations such as the environment, obstructions, and economic concerns were not taken into account in this analysis.

3.1.1 IFR Approach Procedures

3.1.1.1 Independent Parallel IFR Approaches

Currently, the separation between parallel runways must be at least 4,300 feet for simultaneous independent IFR operations. The FAA is actively pursuing ways to improve the minimum separation standard to 3,000 feet using new quick-scan radar technology. The flexibility inherent in having two independent arrival streams is a significant advantage relative to the dependent case in which diagonal separations must be maintained. This may permit an increase of 12-17 arrivals per hour under IFR. Demonstrations using this new radar technology are being conducted in Memphis (MEM) and Raleigh-Durham (RDU).

Preliminary analysis indicates that 26 of the top 100 airports have, or plan to have, parallel runways with spacings between 3,000 and 4,299 feet. With the use of new technology, the candidate sites listed in Table 3-1 could potentially operate independent parallel approaches.

The FAA is pursuing ways to improve IFR separation standards using new quick-scan radar technology. This may permit an increase of 12-17 arrivals per hour under IFR.

Twenty-six of the top 100 airports have, or plan to have, parallel runways with spacings between 3,000 and 4,299 feet.

Table 3-1. Candidates for Independent Parallel IFR Approaches

Potential Annual Delay Savings of Over 1,000 Hours+

Baltimore BWI*	New York JFK
Ft. Lauderdale FLL	Philadelphia PHL*
Memphis MEM	Minneapolis-St. Paul MSP
Raleigh-Durham RDU	

Other Candidates

Atlanta ATL*	Little Rock LIT*
Charlotte CLT*	Long Beach LGB
Cincinnati CVG*	Louisville SDF*
Colorado Springs COS*	New Orleans MSY*
Dallas DAL**	Phoenix PHX
Fort Myers RSW*	Portland PDX
Grand Rapids GRR*	Salt Lake City SLC
Greensboro GSO*	Savannah SAV*
Harlingen HRL	Syracuse SYR*
Kansas City MCI*	

IFR Independent Parallel

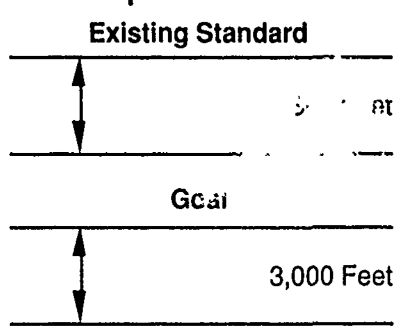

Table 3-1 footnotes

\+ 1989 - 1995 Demand Levels.

* The procedure is applicable upon construction of planned new or extended runways. Savings estimates assume that the new runway will be built at a distance between 3,000 and 4,299 feet from the existing runway.

** The existing parallel runways at Dallas Love (DAL) are 2,950 feet apart.

DEMONSTRATION: **Independent Parallel Approaches**

SITES: Memphis (MEM) Raleigh-Durham (RDU)

MILESTONE	START	FINISH
Demonstration	4/89	10/90
Final Report	10/90	1/91
Procedure Change	2/91	7/91

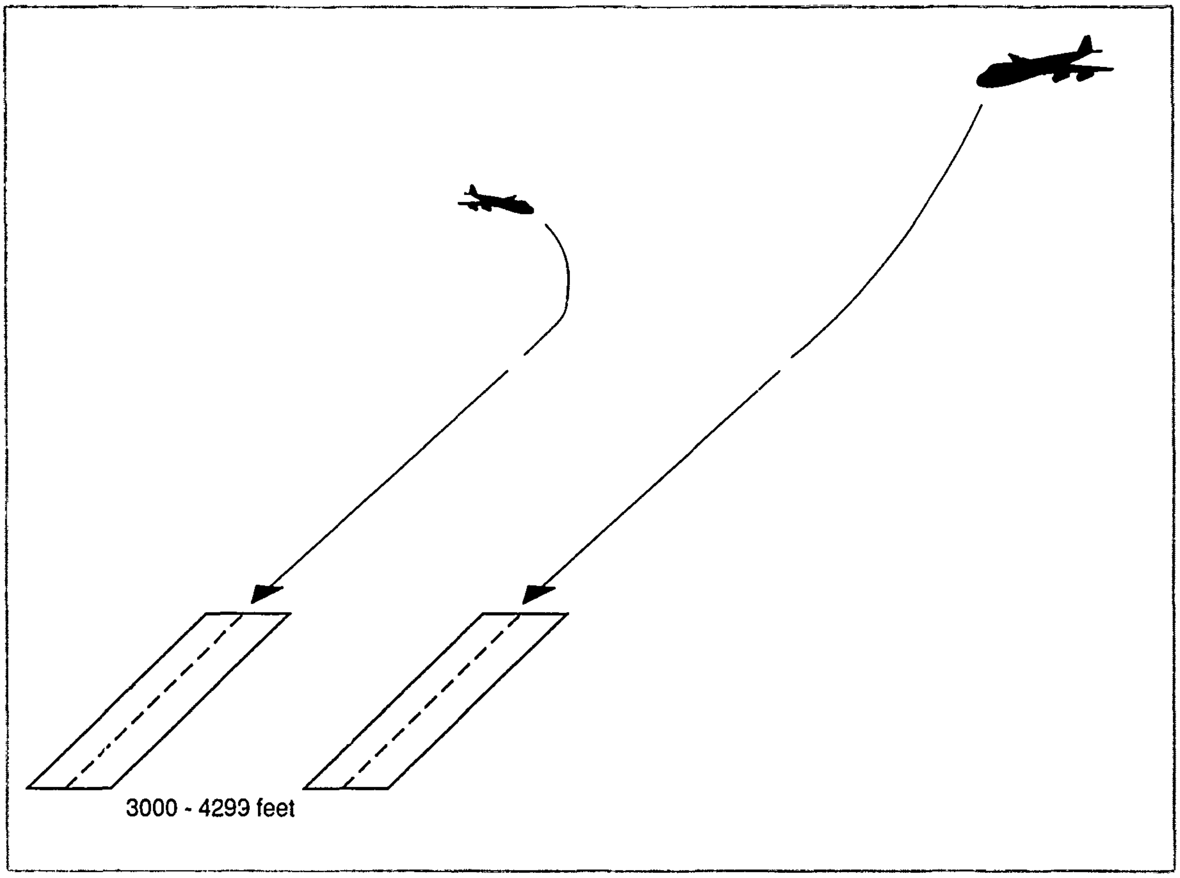

Figure 3-1. Independent Parallel IFR Approaches.

3.1.1.2 Dependent Parallel IFR Approaches

Existing rules require that the separation between parallel runways be at least 2,500 feet for dependent IFR operations with 2.0-nautical miles (nmi) diagonal separation between landing aircraft on adjacent approaches. The diagonal separation requirement prevents a faster aircraft on one approach from passing a slower aircraft on the other approach, limiting the capacity increase associated with using the two arrival streams. Ongoing projects involve an improvement in the 2.0-nmi diagonal separation between aircraft and possibly allowing dependent parallel operations arrivals when the runway separation is less than 2,500 feet.

Recent FAA analyses indicate that this diagonal separation could be safely changed to 1.5-nmi. Furthermore, operational utilization of parallel runways spaced less than 2,500 feet (down to 1,000 feet) might be feasible if solutions to wake vortex hazards are developed. The FAA is currently developing test procedures for dependent parallel operations with 1.5-nmi diagonal separations. Approximately four additional arrivals per hour are possible if improvements in diagonal separation are made to permit 1.5 nmi spacing.

Of the top 100 airports, twenty-six have, or plan to have, parallel runways with spacing between 1,000 and 2,499 feet. These airports are listed below in Table 3-2 as candidates sites for dependent parallel approach operations.

Approximately four additional arrivals per hour are possible if improvements in diagonal separation are made to permit 1.5 nmi spacing.

Of the top 100 airports, twenty-one have, or plan to have, parallel runways with spacing between 1,000 and 2,499 feet

Table 3-2. Candidates for Dependent Parallel IFR Approaches.

Potential Annual Delay Savings of Over 1,000 Hours[+]

Boston BOS

Other Candidates

Atlanta ATL	Milwaukee MKE
Charlotte* CLT	Nashville BNA
Cincinnati* CVG	Oakland OAK
Denver DEN	Omaha OMA
Detroit DTW	Orlando MCO
El Paso ELP	Philadelphia PHL
Indianapolis* IND	Pittsburgh PIT
Knoxville TYS	Providence PVD
Long Beach LGB	Seattle* SEA
Midland MAF	St. Louis STL

IFR Dependent Parallel

Existing Standard

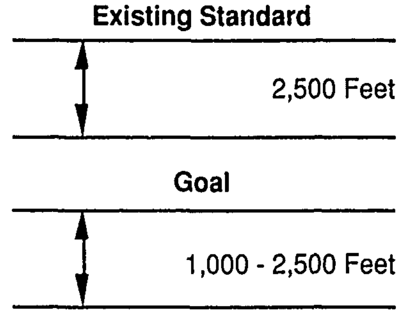

Table 3-2 footnotes

\+ 1989 - 1995 Demand Levels.

* The procedure is applicable upon construction of a planned new or extended runway. Modified dependent parallel approaches will apply if the new runway is built at a distance of less than 2,500 feet from the existing runway.

DEMONSTRATIONS:

1) Improved Dependent Parallel Approaches with 1.5 nmi Diagonal Spacing

SITE: Salt Lake City (SLC), Orlando (MCO)

MILESTONE	START	FINISH
Demonstration	1/90	9/90
Final Report Due	6/90	2/91
Procedure Change	2/91	6/91

2) Dependent Parallel Approaches with 1000-2500 Feet Between Runways

(To be scheduled)

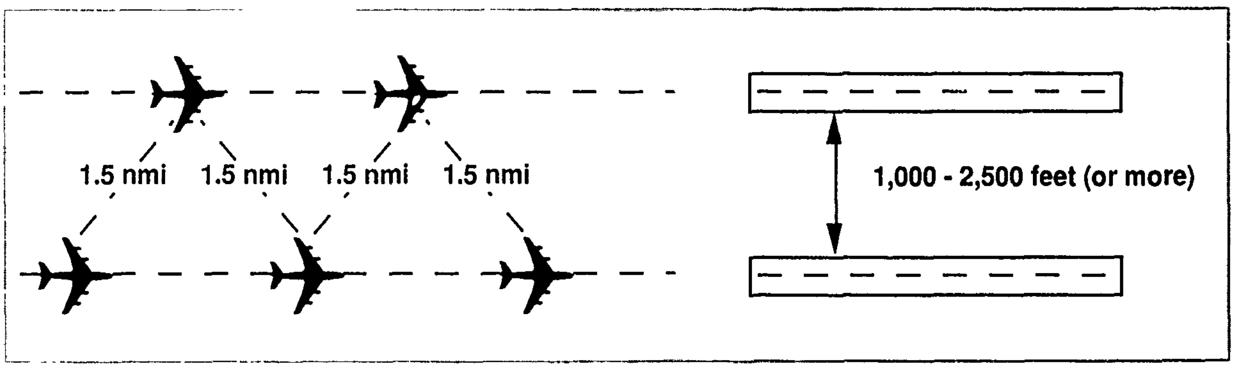

Figure 3-2. Improved Dependent Parallel IFR Approaches.

3.1.1.3 Non-parallel IFR Approaches

The objective of this project is to increase capacity by allowing non-parallel IFR approach procedures for greater periods of time than are possible under current standards used today. Preliminary studies indicate that dependent approaches to non-parallel runways are possible with ceilings down to Category I minima decision heights (200 feet).

Fifty-five of the top 100 airports are candidates for non-parallel approaches.

Preliminary analysis indicates that fifty-five of the top 100 airports are candidates for non-parallel approaches. A program is underway in St. Louis (STL) to demonstrate this concept within the next year. A controller automation aid will be used to maintain aircraft stagger on approach. It is estimated that capacity increases of approximately 8 arrivals per hour over single runway arrival capacity are achievable.

Capacity increases of approximately 8 arrivals per hour over single runway arrival capacity are achievable.

Table 3-3. Candidates for Non-parallel IFR Approaches.

Potential Annual Delay Savings of Over 1,000 Hours+

Boston BOS	St. Louis STL
Cleveland CLE	Washington DCA
Houston HOU	West Palm Beach PBI
San Francisco SFO	

Other Candidates

Albany ALB	Honolulu HNL	Norfolk ORF
Austin AUS	Indianapolis IND	Omaha OMA
Baltimore BWI	Islip ISP	Philadelphia PHL
Buffalo BUF	Kahului OGG	Pittsburgh PIT
Burbank BUR	Las Vegas LAS	Portland PDX
Charleston CHS	Lihue LIH	Portland PWM
Charlotte CLT	Long Beach LGB	Providence PVD
Cincinnati CVG	Louisville SDF	Raleigh-Durham RDU
Colorado Springs COS	Memphis MEM	Reno RNO
Columbia CAE	Miami MIA	Rochester ROC
Dayton DAY	Midland MAF	San Antonio SAT
Des Moines DSM	Milwaukee MKE	Savannah SAV
Fort Lauderdale FLL	Minneapolis MSP	Spokane GEG
Greensboro GSO	Nashville BNA	Syracuse SYR
Harlingen HRL	New York JFK	Tampa TPA
Hilo ITO	Newark EWR	Tulsa TUL

+ 1989-1995 Demand Levels.

DEMONSTRATION: Non-Parallel IFR Approaches

SITE: St. Louis (STL) Philadelphia (PHL)

MILESTONE	START	FINISH
Proof of Concept Demo	3/90	
Simulation at FAA Technical Center	3/90	4/90
Procedure Demo/Data Collection	9/90	9/91
Data Analysis & Report	9/90	2/91
Procedure Change	9/91	10/92

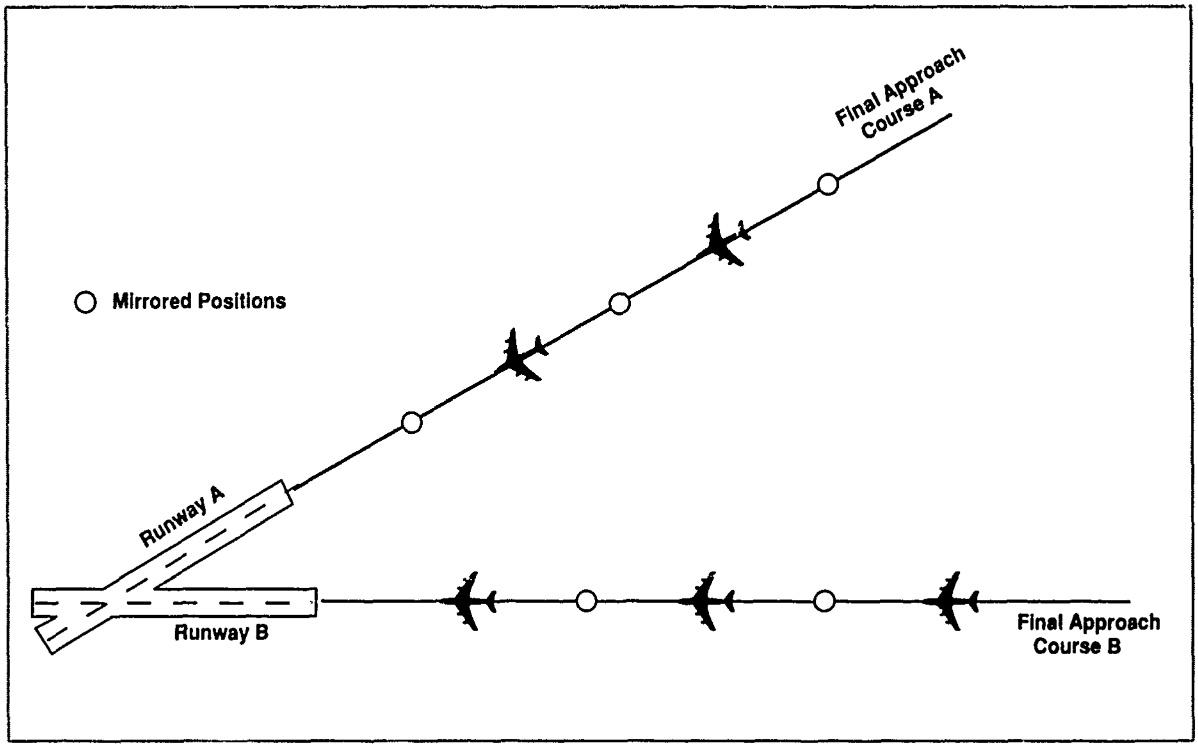

Figure 3-3. Non-parallel IFR Approaches.

3.1.1.4 Triple IFR Approaches

At some airports, combinations of independent IFR parallel operations, dependent IFR parallel operations, and non-parallel runways could be used to implement a system involving triple IFR arrival streams with multiple departure streams. The primary applications of this concept involve airports that have independent IFR arrival streams to parallel runways (using either the 4,300 foot runway separation standard or proposed new independent parallel approach standards). For such airports, a third parallel runway, or a favorably located non-parallel runway, may be used for a third arrival stream. If triple operations were to be permitted in IFR, airports could achieve up to a 50 percent increase in capacity.

Of the top 100 airports, 14 are possible candidates for triple IFR approaches.

Preliminary analysis indicates that, of the top 100 airports, 14 are possible candidates for triple IFR approaches. Chicago (ORD), and Dallas-Ft. Worth (DFW) have existing configurations for triple approaches. Triple approaches were approved for Dallas-Fort Worth Airport in 1989 using two parallel runways and one non-parallel runway.

Table 3-4. Candidates For Triple IFR Approaches.

Potential Annual Delay Savings of Over 1,000 Hours+	
Atlanta ATL*	Pittsburgh PIT*
Chicago ORD	Raleigh-Durham RDU*
Dallas-Ft. Worth DFW*,**	Salt Lake City SLC*
Washington IAD	Orlando MCO*
Detroit DTW*	
Other Candidates	
Cincinnati CVG*	Charlotte CLT
Houston IAH*	Denver (New DVX)
Tulsa TUL*	

\+ 1989 - 1995 Demand Levels.

* The procedure is applicable upon construction of a planned new runway.

** Upon implementation of Triple Parallel Approaches.

DEMONSTRATION: Triple IFR Approaches

SITE: (To Be Determined)

MILESTONE	**DATE**
Simulation at FAA Technical Center	10/88 - 3/91 (Atlanta Configuration)
Flight Demonstrations	Unscheduled
Procedure Change	Unscheduled

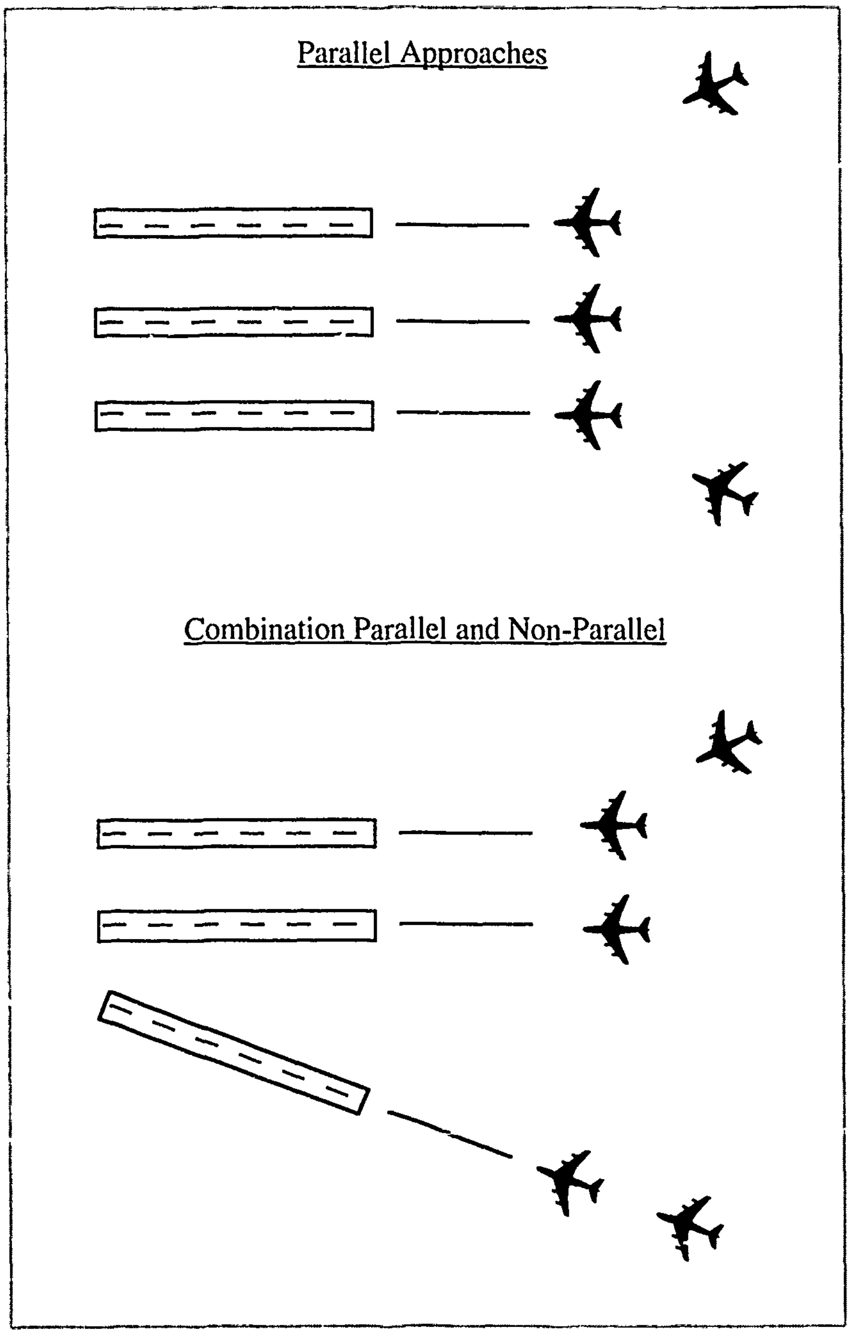

Figure 3-4. Triple IFR Approaches

3.1.1.5 Improved IFR Longitudinal Separation

Air traffic control procedures include minimum longitudinal separation standards for aircraft in IFR approach streams. The separation distances vary from 2.5 to 6 nmi, depending on the relative sizes of the leading and trailing aircraft. The minimum separations are intended to protect the trailing aircraft from leading aircraft wake vortices, and to avoid situations in which the trailing aircraft lands on the runway before the leading aircraft has exited the runway. An improvement in the separation standard from 3.0 to 2.5 nmi between certain classes of aircraft has been recently approved for dry runway conditions. Data have been collected to investigate the same reduction during wet runway conditions at Atlanta (ATL) and Dallas-Ft. Worth (DFW). Research is going on to investigate properties of wake vortices that may permit reductions below 2.5 nmi.

Improved longitudinal separation procedures can provide potential capacity gains of three to five arrivals per runway per hour.

Most airports will benefit from the improved longitudinal separation standards. These procedures can provide potential capacity gains of three to five arrivals per runway per hour.

Table 3-5 shows those airports already approved to operate under the new longitudinal separation standard.

Table 3-5. Airports Approved to Use New IFR Longitudinal Separation on Final Approach.

Atlanta ATL	New York JFK
Baltimore BWI	New York LGA
Boston BOS	Newark EWR
Charlotte CLT	Norfolk ORF
Chicago ORD	Orlando MCO
Cincinnati CVG	Philadelphia PHL
Dallas-Ft. Worth DFW	Pittsburgh PIT
Denver DEN	St. Louis STL
Houston IAH	Tampa TPA
Los Angeles LAX	Washington DCA
Nashville BNA	Washington IAD

DEMONSTRATION: Improved In-Trail Spacing on Wet Runways

SITE: Salt Lake City (SLC)

MILESTONE	START	FINISH
Demo	1/90	9/90
Report	6/90	10/90
Procedure Change	10/90	1/91

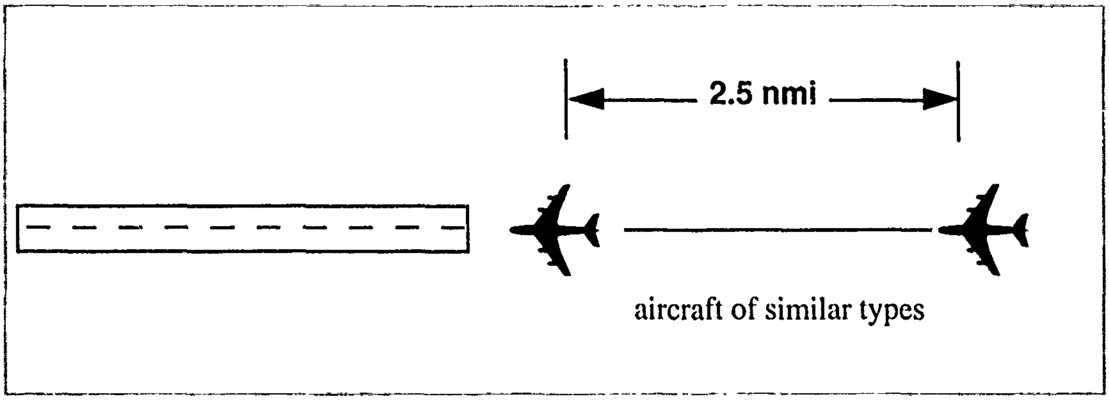

Figure 3-5. Improved In-trail Spacing on Wet Runways.

3.2 Airspace Planning

Airspace design involves extensive coordination between air traffic controllers and airspace planners. Several efforts are underway to improve the efficiency of the airspace system. Airspace Capacity Design Projects are either completed or underway at 10 major areas in the United States.[3]

Annual flight delay savings from the individual projects range into thousands of hours and millions of dollars.

The FAA has focused on several critical capacity and delay problems using simulation models as tools in identifying and evaluating potential solutions.[4] These applications included evaluating alternatives to realign airspace, redesign routings, and revise procedures to enhance the efficiency and safety of air traffic operations. Computer modeling was used to quantify delay, travel time, capacity, sector loading, and aircraft operating cost impacts of new proposed airspace structures, routings, and procedures. Studies were completed at Boston, Chicago, Dallas-Fort Worth, and Los Angeles. Studies are currently being performed for airspace near Houston/Austin, Kansas City, New York, Oakland, Cleveland, and Washington Center.

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3. A description of the results and/or status of each is included as Section 3.2.1 and Section 3.2.2.
4. See Section 4.4.3, Sector Design Analysis Tool, and Section 4.4.4, Terminal Airspace Visualization Design Tool.

Table 3-6. Airspace Capacity Design Projects

Completed	Underway
Boston	Cleveland
Chicago	Houston/Austin
Dallas/Ft. Worth	Kansas City
Los Angeles	New York
	Oakland
	Washington

Completed Projects:

Completed projects, which have involved supporting airport and airspace planning efforts aimed at increasing capacity and reducing delays, include:

Boston	• Redesign of en route airspace routings, sectorization, and procedures.
Chicago	• Assessment of potential operational alternatives in the Chicago area, including airspace realignment and new runway at O'Hare Airport.
Dallas/Fort Worth	• Evaluation of terminal airspace redesign, potential airport facility improvements and operational alternatives.
Los Angeles	• Realignment of terminal and en-route airspace to relieve saturation problems.

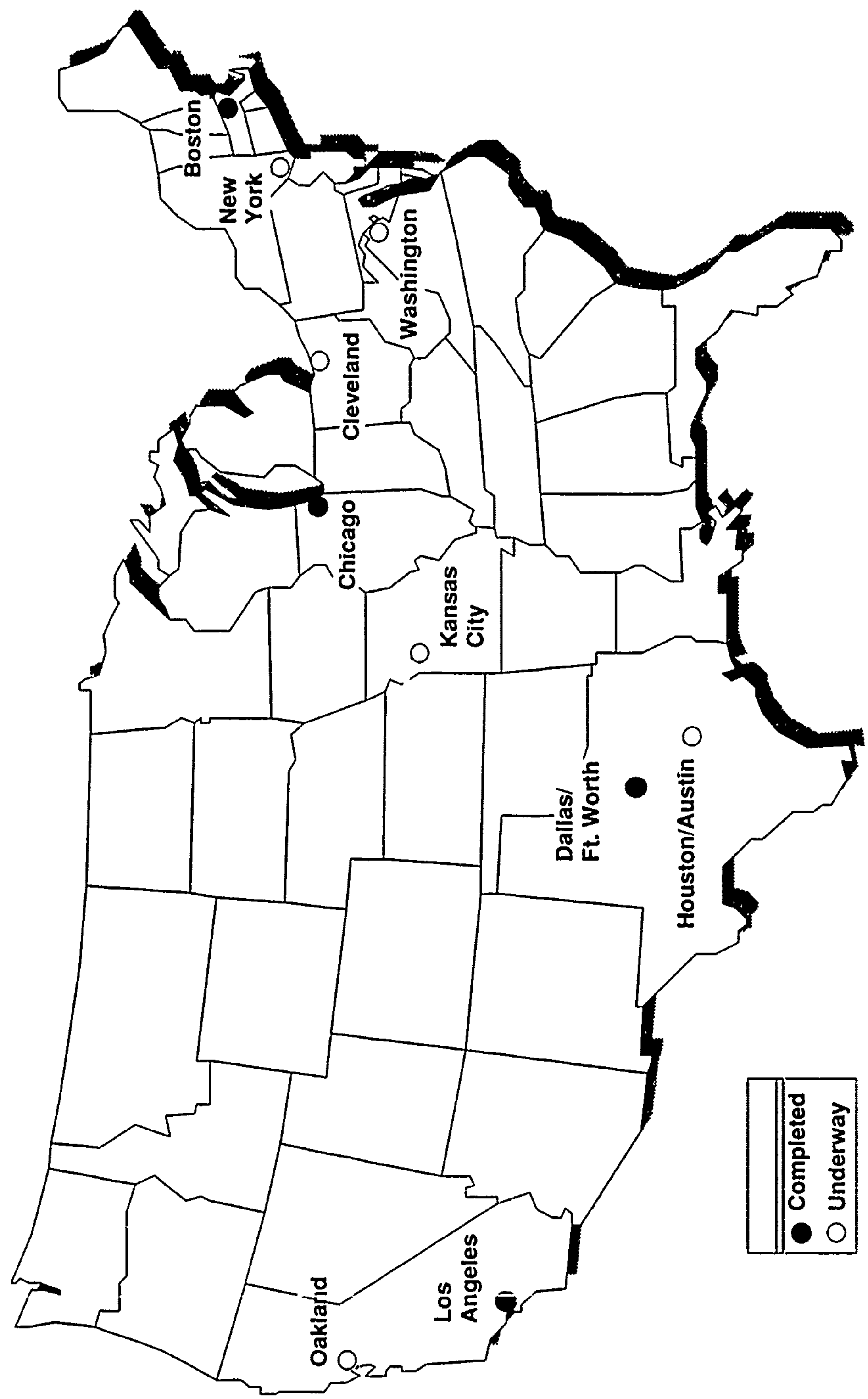


Figure 3-6. Airspace Capacity Design Projects

3.2.1 Completed Airspace Design Projects

3.2.1.1 Boston

- Boston Center airways were realigned to provide more direct routings.
- Departure routes were realigned with revised New York Center routings.
- More efficient routings for arrivals were implemented.
- Sectors were revised to allow for uniform distribution of the traffic load among the various sectors.
- Airspace sector complexity was reduced by providing for a reduced amount of "shelving."

Table 3-7. Boston — Delay Reductions and Cost Savings for the New System

Percent Increase in Traffic	Average Daily Flight Time Reduction	Cost per Aircraft Flight Hour	Annual Cost Savings (in millions)
0%	41 hours	$1,600	$23
10%	52 hours	$1,600	$30
20%	81 hours	$1,600	$47
30%	109 hours	$1,600	$63
40%	141 hours	$1,600	$82
50%	212 hours	$1,600	$123

3.2.1.2 Dallas/Ft. Worth

Major airspace modifications include:

- Expand TRACON airspace from 30 to 40 miles
- Relocate cornerpost NAVAIDS and add two new NAVAIDS
- Establish dual jet routing for arrivals over each cornerpost
- Establish additional terminal departure routes
- Segregate jet, turboprop, and prop traffic
- Segregate some military from civilian aircraft
- Revise nominal radar vector paths within the TRACON
- Revise arrival and departure routings in the Fort Worth Center.

Table 3-8. Dallas/Ft. Worth — Aircraft Operating Cost Savings for the New System.

Year	Annual Cost Savings
1990	$13 Million
2000	$32 Million
2010	$237 Million
Cumulative Savings from 1990 thru 2010:	$1696 Million

3.2.1.4 Chicago

The purpose of this study was to evaluate the impact on the airspace of operations in the Chicago area and to propose changes to the airspace structure.

The study considered several near term improvements to the arrival and departure corridors and found potential delay savings of $13 M to $25 M.

Several long term improvements such as rotating the corner post arrival fixes and adding a new runway could result in delay savings of $40 M to $250 M per year.

Table 3-10. Aircraft Operating Cost Savings for O'Hare Airport Traffic for Various Airport/Airspace Improvement Options.

Improvement Option		Annual Cost Savings			Cumulative Savings
Airspace	Runways	1989	1995	2020	1989 thru 2020
Rotate	Existing Runways	$37 M	$40 M	$52 M	$1.4 B
Existing	2 New Runways	$98 M	$208 M	$304 M	$8.0 B
Rotate	2 New Runways	$137 M	$254 M	$412 M	$9.7 B
Existing	1 New Runway	$54 M	$114 M	$187 M	$4.4 B
Rotate	1 New Runway	$92 M	$158 M	$250 M	$6.0 B

3.2.1.3 Los Angeles

Major modifications to the old system include:

- Expanding the lateral boundaries of Coast TRACON.
- Establishing a common ceiling of 13,000 feet for Coast and Los Angeles TRACONs.
- Assigning departures from Los Angeles International Airport previously using a northeastern routing to an eastbound routing.
- Assigning departures from Orange County and Long Beach airports currently on northern routings to an eastbound routing.
- Assigning departures from Orange county and Long Beach airports currently on northern routings (previously handled by Sector 21) to Coast TRACON for routing to the west.
- Assigning southbound arrivals to Coast TRACON earlier, with Coast TRACON keeping this traffic under Long Beach and Orange County departures being worked to the west.

Realignment of Los Angeles Basin Airspace will relieve the airspace saturation in Los Angeles Center Sector 21 and result in substantial improvements in efficiency.

Table 3-9. Los Angeles — Delay Reductions and Cost Savings for the New System.

Traffic Demand Level	Additional Average Commercial Flights	Daily Flight Time Reduction	Cost per Aircraft Flight Hour	Annual Cost Savings (in Millions)
Near Term	98	13 hours	$1,600	$8
Nominal (yr 2000)	156	39 hours	$1,600	$23
High Growth (yr 2000)	195	70 hours	$1,600	$41

3.2.2 Current Airspace Projects

3.2.2.1 Kansas City Area Airspace

The study began in August 1989, and in expected to be completed in 1990. Tentative problems and issues to be addressed in the Kansas City Area Air Traffic project include:

- Evaluation of the alternatives associated with St. Louis TRACON taking approach control responsibilities for Scott AFB.
- Analysis of the impacts on traffic operations of operating Scott AFB as a joint use airport.
- Assessing the impact of adding runways as Kansas City International Airport.
- For both St. Louis and Kansas City terminal airspace structures, evaluate alternatives involving:
  - modified arrival and departure routings and procedures
  - segregation of satellite/primary arrival tracks
  - impacts of reconfigured airspace using four-corner post concepts
  - future demand levels for VFR and IFR conditions
- Analysis of the impact on Kansas City ARTCC of increased overflight traffic associated with airport expansions in Dallas/Ft. Worth, Denver, and Chicago.

3.2.2.2 Houston/Austin Airspace

The Houston Airspace Study will examine the following issues:

- Houston Center's capability to deliver traffic for the new Austin Airport operating with triple ILS's
- Benefits of segregated traffic (dual routes versus single routes based on aircraft performance) including the impact on Bergstrom AFB
- Effects of relocating the Brady Military Operations Area
- Effects of Austin Executive Airports as a reliever airport
- Effects of rerouting of East Coast traffic (ATL)

The project began in August 1989 and will be completed in 1990.

3.2.2.3 New York Area Airspace Study

The objective of this study is to examine airspace improvements in the New York Area. Because of the complexity of the New York Area, the first phase of the project, to be completed in 1990, is to set up and calibrate the simulation model to be used in the study.

The model will then be used to restructure the airspace to improve traffic flows by re-routing certain traffic around and through the area.

3.2.2.4 Oakland Area

The Oakland area study has just begun and is expected to be completed in 1991.

The study will evaluate the interactions between Oakland, San Francisco, Nellis AFB, and traffic from other major airports in the Oakland Center Airspace.

Tentative problems and issues to be addressed in the Oakland Airspace Capacity Project include:

- Potential airspace realignment to alleviate the complexity and saturation problems associated with Oakland ARTCC Sector 11.
- The impacts on civilian traffic of proposed expansion of special use airspace in the Fallon, Nevada, area, which includes Nellis Air Force Base training areas.
- Evaluate the proposed Northern California Metroplex Control Facility airspace redesign, which would consolidate operations in Bay, Sacramento, Stockton, Monterey, Merced, and Travis approach controls.
- The capacity gains afforded by new runway facilities in the San Francisco bay area include:
  - New runway 29 at Oakland
  - New runway 28 at San Francisco
  - Extension of Runway 30R at San Jose
  - High speed exit from Runway 30L at San Jose
- Identify and quantify potential benefits of employing MLS at San Francisco, Oakland, San Jose, and Sacramento Airports.
- Evaluate impacts of increased traffic at San Jose Airport due to the proposed closure of Reid-Hillview Airport.

3.2.2.5 Cleveland and Washington Centers

The two studies will establish two computer simulation models to study the airspace for the Cleveland and Washington ARTCC's and will be completed in 1991.

Chapter 4

New Technology for Capacity Improvement

The major thrust of the R, E&D program is directed toward managing an expanding volume of air traffic with improved safety, reduced delays, and minimal operational constraints.

• Major 1989 Accomplishments

During 1989 the FAA's Capacity R,E&D program accomplished:

- Prototype surveillance radars with increased update rates were installed at Raleigh-Durham and Memphis to examine their ability to monitor flight paths for independent, simultaneous approaches to closely-spaced parallel runways. These systems can potentially provide an estimated 30 percent increase in capacity at those sites during IFR.
- Airport capacity improvement studies supported by FAA planning and analysis tools were completed at Atlanta, San Francisco, Detroit, St. Louis, Miami, and Kansas City. As a result, new runways are being planned at four of these airports.
- Potentially significant capacity gains through more efficient use of runways were simulated using a prototype converging-approach spacing aid.
- Recently completed computer-based analytical models were applied successfully to evaluate terminal area airspace designs at the Los Angeles, Boston, Dallas/Fort Worth, and Chicago air traffic centers.

• Current Program

The major thrust of the program is directed toward closing the gap between IFR and VFR capacities while maintaining maximum VFR capacity. Complete project details, including funding and implementation dates where appropriate, are given in Appendix F. The key elements of the R,E&D capacity program are as follows:

- Continued development of precision landing monitors and procedures permitting independent IFR approaches to parallel and converging runways.
- Continued development of terminal area and airport surface traffic automation. The surface traffic automation effort seeks to prevent runway incursions and improve surface traffic management. The terminal area automation activity will employ modern computer displays and computational power for increased terminal area capacity and safety. Both systems will be integrated into the Advanced Automation System under current development.
- Continuation of an ambitious schedule of airport capacity design team studies.
- Continued analysis and study of methods and procedures to utilize triple and quadruple parallel approaches at selected airports.
- Further application of airspac ; models and traffic flow simulations for the determination of optimal airspace structure and procedures to enhance capacity.
- Aggressive pursuit of a program to determine means and procedures to alleviate the adverse impacts of aircraft wake vortices on airport capacity.
- Continuation of efforts to improve airport pavements, runway maintainability, and surface lighting and marking to reduce runway and taxiway occupancy time.

4.1 AIRPORT AND TERMINAL AIRSPACE CAPACITY TECHNOLOGY

4.1.1 Precision Runway Monitor (PRM)
4.1.2 Mirror Imaging
4.1.3 Microwave Landing System (MLS)
4.1.4 Traffic Alert and Collision Avoidance System (TCAS)

4.2 EN ROUTE AIRSPACE CAPACITY TECHNOLOGY

4.2.1 Automatic Dependent Surveillance (ADS) and Oceanic ATC
4.2.2 Automated En Route ATC (AERA)
4.2.3 Advanced Traffic Management System (ATMS)

4.3 AIRPORT SURFACE CAPACITY TECHNOLOGY

4.4 TECHNOLOGY FOR PLANNING INITIATIVES

4.4.1 Computer Simulation Models
4.4.2 National Airspace Management Facility (NAMFAC)
4.4.3 Sector Design Analysis Tool
4.4.4 Terminal Airspace Visualization Tool

4.1 Airport and Terminal Airspace Capacity Technology

The development and implementation of each of the technology areas described in the following sections offer significant promise to improve the capacity of an airport and its surrounding terminal airspace. For example, provision of a precision runway monitor (PRM) would enable an improvement in the minimum spacing required for independent operations to parallel runways by improving the quality of approach surveillance. Use of an automation aid such as mirror imaging would provide controllers with the means to operate non-parallel runways safely, by keeping aircraft staggered on approaches. The wide-area coverage and multiple glide slope capability of the Microwave Landing System (MLS) offers an expansion as well as improvement in the provision of precision approach and landing services throughout the NAS; appropriate uses for this technology may offer significant capacity gains.

Supplementing ground-based ATC services such as PRM and MLS with the aircraft-based Traffic Alert and Collision Avoidance System (TCAS) would not only enhance the safety of terminal operations, but could provide potential to support further improvement in the spacing of arrival flows.

4.1.1 Precision Runway Monitor

Where closely spaced parallel runways exist, significant capacity gains at a single airport can be achieved through implementation of precision runway monitor (PRM) systems. Current criteria allow independent approaches to be conducted to parallel runways separated by 4300 feet or more. This standard was established based on the surveillance rate and accuracy of the airport surveillance radars (ASR) and the terminal Advanced Radar Tracking System (ARTS) capabilities. Subsequent analysis has indicated that the separation between parallel runways could be improved if the surveillance data rate and accuracy were upgraded.

Implementation of precision runway monitors at airports with parallel runways spaced between 3000 feet and 4300 feet may permit use of independent simultaneous parallel approaches and will provide up to a 40% increase in capacity over that achievable with dependent approaches, while maintaining or even increasing the level of safety in aircraft separation. Addition of a new runway with independent simultaneous parallel approach operations could provide up to a 100 percent increase in capacity in instrument meteorological conditions at some airports.[1]

The precision runway monitor program is designed to reduce the time it takes the radar to display an aircraft deviation from the final approach path, and the time it takes the controller to see it on the display and react to it. Conventional airport surveillance radars update the target position approximately every 5 seconds. Each second of improvement in the update rate results in an improvement in allowable runway spacing of 240 feet. Hence, with an improvement of 4 seconds, the minimum runway spacing can be improved from 4300 feet to 3380 feet.

Aside from the update rate, additional time can be saved with a more accurate radar and an improved display. These improvements would allow a controller to be certain that a blunder is occurring because the deviations from the on-course track are easier to recognize, allowing the controller to declare the blunder earlier. Further computer processing of the track allows generation of an automated alert to the controller, lessening the reaction time.

The PRM system consists of an improved antenna system that provides high azimuth and range accuracy and higher data rates than the current terminal ASR radars, a processing system that monitors all approaches and generates controller alerts when an aircraft appears to be blundering, and a high resolution display system.

The FAA is evaluating two versions of the PRM system. One system utilizes an electronically scanned antenna that allows aircraft positions to be updated every half second. The other system utilizes two mechanically rotating antennas mounted back-to-back and provides an update of aircraft positions every 2.4 seconds.

Two field sites have been selected to serve as operational evaluation facilities to prove the radar and explore the assumptions inherent in deciding whether today's 4300 feet minimum standard for independent parallel approaches can be improved. The electronic scan antenna system has been installed at the Raleigh-Durham airport, and the back-to-back rotating antenna system has been installed at the Memphis airport.

Demonstrations will be run throughout the first three quarters of 1990, and a demonstration report is expected in 1990.

1. If runways are spaced at least 2,500 feet, but less that 4,300 feet apart, the controller must employ dependent parallel approach procedures during IFR conditions, ie: require that a diagonal spacing of at least 2 mni be maintained between aircraft approaching adjacent runways. This spacing constraint means that an airport without the requisite spacing between runways suffers a capacity penalty of about 40% during instrument weather conditions.

4.1.2 Mirror Imaging

Mirror Imaging is the application of a proposed automation aid that, in addition to displaying an aircraft at its actual location, will also display a mirror image at another location on the controller's display. Such mirror image targets can assist air traffic controllers in assessing the relative position of aircraft that are on two different paths. This technique was originally proposed for facilitating staggered approaches to non-parallel runways. FAA is currently developing operational tests for the use of the mirror imaging automation aid for precision converging approaches to Cat I minima, which can currently only be used up to high IFR ceilings.

The concept may also have application under VFR. For example, it could be used at airports with intersecting runways that have insufficient length to allow hold short operations. Insufficient runway length between the threshold and the intersection with another runway can be ignored if arrivals are staggered such that one is clear of the intersection before the other crosses its respective threshold.

4.1.3 Microwave Landing System (MLS)

Subsequent to the year 2000, the United States intends to transition from the Instrument Landing System (ILS) to the Microwave Landing System (MLS). The MLS offers the users potential National Airspace System (NAS) operational benefits. These benefits include the capability to perform curved approaches with a short final straight-in segment, relief for ILS frequency congestion, more flexible ground equipment siting, use of back azimuth guidance, use of higher glide slopes, and area navigation (RNAV) capability with a wide area of coverage.

The ILS has provided dependable precision approach service for many years. However, inherent characteristics of the ILS have limited its employment and caused difficulties in congested terminal areas. Of particular concern from an air traffic perspective is the single straight-in flight path required by ILS. This restriction is not a major concern for isolated airports without obstruction problems, but for closely spaced airports in high density areas, the long straight-in ILS finals create congestion because flight paths often cross at a distance that precludes separation by altitude. In these configurations the airports become inter-dependent (i.e., operations cannot be conducted simultaneously at affected airports), causing delays and decreasing capacity throughout the NAS. In areas such as New York, the curved approach capability

provided by MLS may provide a solution to the inter-dependency of proximate airports.

The MLS will also enable the FAA to provide precision approach capability for airports and runways at which an ILS could not be utilized due to ILS localizer frequency-band congestion. The ILS has only 40 channels available in its frequency band, and congestion is becoming a serious problem in several parts of the country. For example, it is already difficult to add ILS facilities in congested areas such as Los Angeles and New York. The MLS has two hundred operational channels with additional channels available for future growth and development.

The MLS will allow provision of precision approaches in areas that do not permit ILS applications due to rough terrain or large structures. As a consequence of the inherent signal stability of MLS, and its immunity to interference that plagues the ILS, more airports and runways can install MLS, and site preparation costs can be reduced. It may also be possible to achieve lower minima with MLS than can be achieved with ILS at some sites. Moreover, MLS may relieve surface congestion caused by ILS sensitivity to reflecting surfaces such as taxiing and departing aircraft.

Use of MLS back azimuth for IFR missed approach guidance may help support development of approach procedures for converging runways and triple runway configurations. Use of back azimuth for departure guidance may help ease airspace limitations and restrictions on aircraft operations due to noise abatement requirements.

The MLS/RNAV capability with wide area coverage will provide more flexibility in the terminal airspace. It should permit the design of instrument approach procedures that more closely approximate traffic patterns used during VMC that use shorter flight paths, segregation of aircraft by type, reduction of arrival and departure gaps, and avoidance of noise sensitive areas.

4.1.4 Traffic Alert and Collision Avoidance System (TCAS) Applications

The Traffic Alert and Collision Avoidance System (TCAS) is a family of airborne systems that operate independently of ground-based ATC, and provide the pilot with advisories concerning nearby transponder-equipped aircraft. The system mandated for use in transport category aircraft, TCAS II, provides relative position information and, when necessary, advisories for vertical maneuvers to avoid collisions. This system is expected to be fully implemented on transport carrier aircraft by the end of 1993.

Because of the information provided by TCAS and its widespread equipage, it has been identified as having the potential to increase ATC capacity and efficiency, and reduce controller workload and staffing.

A program is being established to investigate concepts to support improved spacing on final approach; improve the stagger requirement for dependent converging approaches using the mirror imaging controller aid; allow departures at improved spacing; monitor separation between aircraft on independent approaches; and other capacity-enhancing operations. Should these applications prove successful, additional development will be pursued in the areas of wake vortex avoidance, TCAS-based parallel approach monitoring, TCAS-based self-spacing, and other more advanced applications.

4.2 En-route Airspace Capacity Technology

En route airspace congestion is being increasingly identified as a factor in restricting the flow of traffic at certain airports.

One cause of en route airspace congestion is that ATC system users want to travel directly from one airport to another at the altitude best for their aircraft, and hundreds of aircraft have similar performance characteristics. Therefore, some portions of airspace are in very high demand, while others very little. This non-uniform demand for airspace translates into many problems for effective en route airspace management, such as the need to devise equitable strategies for distributing the traffic when demand exceeds capacity.

Means of achieving greater capacity for the en route environment will be discussed in the following sections:

- Automatic Dependent Surveillance (ADS) and Oceanic ATC will make it possible to effect significant improvements in Oceanic en route spacing.
- Automated En Route Air Traffic Control (AERA) will assist the controller in assigning aircraft to their preferred routes.
- Automated Traffic Management System (ATMS) will provide a real-time planning tool for more efficient use of airspace.

Other means of improving en route airspace capacity include:

- Improving the vertical spacing limitations at altitudes above 29,000 feet to allow more turbojet aircraft to operate at their preferred altitudes.
- Allowing on-line flight planning through the Direct User Access Terminal (DUAT) to permit non-scheduled users to plan routes using uncongested portions of airspace.
- Shortening the minimum in-trail spacing requirement can increase the flow rate on an airway.

4.2.1 Automatic Dependent Surveillance (ADS) and Oceanic ATC

The operation of an ATC system depends on accurate and timely reports of the aircraft's position in space and good pilot-controller communications. The present Oceanic ATC system uses hourly reports by the pilot to determine the aircraft's position. The pilot-controller communications link depends on High Frequency

(HF) voice transmissions. There is no separate surveillance channel. Oceanic ATC is largely manual and procedural, with aircraft frequently being confined to fixed tracks with limited options for changing flight plans. Because of the uncertainty and infrequency of the position reports, separations much larger than domestic separations are maintained to assure safety. These large separations effectively restrict available airspace, and aircraft must often operate on less than optimal routes.

The limitations of the present Oceanic ATC System are recognized not only by the FAA, but also by the world aviation community, the International Civil Aviation Organization (ICAO), and the ICAO Special Committee on Future Air Navigation Systems (FANS). These organizations have aggressively pursued the development and implementation of an Automatic Dependent Surveillance (ADS) function in Oceanic airspace.

The concept of ADS using satellite technology will revolutionize ATC in the large Oceanic areas beyond the coverage of land-based radar. ADS is a technique whereby the information generated by an aircraft's onboard navigation system is automatically relayed from the aircraft, via a satellite data link, to the ATC facilities. The automatic position reports will be displayed to the air traffic controller in seconds rather than the several minutes of delay in today's system.

ADS will be a part of a new Oceanic ATC system to support transoceanic flights over millions of square miles of Pacific and Atlantic airspace. This new Oceanic ATC system will provide an automation infrastructure including oceanic flight data processing, a computer-generated situation display, and a strategic conflict probe for alerting controllers to potential conflicts hours before they occur. The first phase of the new system, the Oceanic Display and Planning System (ODAPS), became operational in the Oakland Air Route Traffic Control Center (ARTCC) in December 1989, and is scheduled to become operational in the New York ARTCC in 1990. In 1991, real-time position reporting via ADS will be added to the system and in 1993 direct pilot-to-controller communication using the satellite data link will become operational.

The new Oceanic ATC system will provide benefits to airspace users in several areas—safety, efficiency, and capacity. The improved position reporting will allow better use of the existing separation standards. Air traffic management can begin the process of reducing those standards, thereby increasing the manageable number of aircraft per route. The strategic conflict probe will allow controllers to evaluate traffic situations hours into the future. Ultimately, controllers will be able to grant more fuel-efficient direct routes. These improvements in efficiency and capacity will have a dramatic impact on fuel costs and delays.

4.2.2 Automated En-route Air Traffic Control (AERA)

One of the key elements of the NAS Plan is the Advanced Automation System (AAS), which provides new hardware and software to be used in ATC facilities. AAS is scheduled to be implemented in the 1990's. AAS will incorporate functions of, and enhancements to, the currently fielded ATC system. AAS will also introduce a collection of automation capabilities known as Automated En Route ATC (AERA).

AERA will support ATC personnel in the prediction and resolution of problems along an aircraft's flight path, and in the planning of traffic flows. AERA will increase airspace capacity by improving the ATC system's ability to manage more densely populated airspace. AERA will also improve the ability of the ATC system to accommodate both user-preferred routes and direct routes. When the most desirable routes are unavailable because of congestion or weather conditions, AERA will assist the controller in finding the open route closest to the preferred one.

The AERA capabilities are defined as follows:

- <u>AERA 1</u> introduces capabilities within the AAS software to detect ATC problems corresponding to an intended route of flight, and to display problem information to a sector controller.
- <u>AERA 2</u> It adds the capability of automatically generating solutions to the problems detected in AERA 1, and displaying alternative resolutions of a problem to the controller. It enhances the AERA 1 automation capabilities that assist the controller with ATC separation and coordination tasks.
- <u>AERA 3</u> is the most highly automated phase of the AERA program. The essence of AERA 3 is to automate the aircraft separation assurance function. The human ATC specialist becomes a manager of traffic flow, planning and selecting strategies rather than directing the flight paths of individual aircraft. AERA 3 takes advantage of advanced avionics systems such as flight management systems and data link.

Laboratory facilities for the AERA 2 program were established at the MITRE Corporation in McLean, VA, in 1987. This laboratory has been used for prototyping and analyses to develop operational and specification materials, as well as associated supporting

technical documentation. These algorithmic and performance specifications and candidate ATC procedures will be completed in 1991.

In the next phase of the AERA 2 program, the AAS contractor will produce and integrate the AERA 2 software within the AAS (which already includes AERA 1), and support the operational evaluation at the FAA Technical Center. The AERA 2 software and the ATC procedures will be updated as a result of the operational evaluation. This operational evaluation phase has already begun, and is scheduled to continue through 1997.

In 1989, the AERA 3 program accomplished the first prototype of an ARTCC in an AERA 3 environment which simulates an integrated automation of the separation and planning functions. The Protocenter has successfully separated aircraft in realistic simulation scenarios consisting of over 100 aircraft. In 1990, the Protocenter was enhanced to include a metering function, so that it will not only keep aircraft separated, but will also develop time schedules and generate clearances to ensure that aircraft meet assigned time constraints, such as metering into terminal areas. Another recent enhancement to the Protocenter is a set of functions to cope with data uncertainties resulting from imperfect knowledge of winds aloft or aircraft speeds. In addition to the Protocenter, the AERA 3 program is investigating the human role in a highly automated ATC environment, using a team of controllers, pilots, and specialists in traffic management and meteorology.

The research and development phase of AERA 3 is scheduled to be complete in 1995, and will include a procurement specification as well as the concept design and prototype testing. The Facilities and Equipment contract award is expected in 1997, with Initial Operating Capability anticipated in 2002, and Operational Readiness Demonstrations in 2003.

4.2.3 Advanced Traffic Management System (ATMS)

The mission of the Traffic Management System is to minimize the occurrence of NAS overload effects on user preferences without compromising safety. This is accomplished by:

- Monitoring the demand on, and capacity of, ATC resources
- Developing alternative strategies to balance demand and capacity to prevent critical entities from being overloaded
- Coordinating and implementing strategies to assure maximum use of critical resources when a demand/capacity imbalance is predicted or detected.

The Aircraft Situation Display was the first capability developed by ATMS. The Aircraft Situation Display generates a graphics display that show current traffic and flight plans for the entire NAS. The Aircraft Situation Display is currently being deployed at the Central Flow Control Facility, all Air Route Traffic Control Centers, and selected TRACONs. The Aircraft Situation Display has increased system capacity in several ways.

- Aircraft Situation Display allows Traffic Management specialists to observe approaching traffic across ARTCC boundaries. This has enabled the reduction or elimination of many fixed miles-in-trail restrictions (and the resultant delay of aircraft) that were in effect prior to the deployment of Aircraft Situation Display.
- Aircraft Situation Display allows Traffic Management specialists to detect and effect solutions to certain congestion problems, such as merging traffic flows well in advance of problem occurrence, even before the aircraft enter the ARTCC where the congestion problem will occur. Small adjustments to traffic flows made early can avoid large delays associated with last minute solutions.
- Aircraft Situation Display assists Traffic Management specialists in planning arrival flows, especially for airports that are close to ARTCC boundaries. Smoother arrival flows result in better airport utilization.

The second capability developed by ATMS was Monitor Alert. Monitor Alert attempts to predict traffic activity several hours in advance. Monitor Alert compares the predicted traffic level to the threshold alert level for air traffic control sectors, fixes, and airports, and highlights predicted problems. Monitor Alert is currently undergoing evaluation at the Central Flow Control Facility. If Monitor Alert is successful, congestion problems will be detected further in advance, enabling solutions to be implemented earlier.

Three future capabilities that are being developed through ATMS are Automated Demand Resolution, Strategy Evaluation, and Directive Distribution. Automated Demand Resolution will examine problems predicted by Monitor Alert and suggest several alternative problem resolutions. The solutions suggested by Automated Demand Resolution respond to each problem without creating conflicts or additional problems. Strategy Evaluation will provide a tool for the specialist to compare suggested resolutions. Directive Distribution will automatically distribute the necessary flow directives to implement the selected resolution.

4.3 Airport Surface Capacity Technology

The three major functions of the Air Traffic Control Tower are to provide for safe and efficient capacity runway operations (including aircraft on the approach path and the runway), to manage and control the movement of taxiing aircraft on the airport surface movement area (principally between the runway and gate), and to provide to pilots services related to flight route clearances and airport advisories and conditions. Currently the system is predominantly a manual/visual system.

The runway/approach path safety system that will be provided by Airport Surface Traffic Automation (ASTA) programs will include a surveillance/automation capability that provides tower controllers with real-time data on the location and motion of all aircraft/vehicles, with target identity on the airport surface and the final approach path. This capability will eventually provide an integrated display presentation of the runway/approach path situation, designed to prevent conflict situations from developing. It will provide for an automatic detection and presentation to controllers of warning and conflict situations; and direct automatic communications with the cockpit for ATC clearances, the airport traffic situation, and automatic emergency conflict resolutions messages. This capability will provide an all weather, automated capability that allows for safe high-capacity operations under all conditions. A major portion of these safety benefits can be achieved by the Airport Movement Area Safety System (AMASS), an early runway incursion protection capability.

AMASS will add an automation enhancement to the Airport Surface Detection Equipment-3 (ASDE-3) to provide conflict alert algorithms for tower controllers to prevent and detect runway incursions and accidents. The AMASS would be used by Local and Ground controllers at the 29 operational ASDE-3 sites. The system also includes a track data interface with the Automated Radar Terminal System IIIA (ARTS IIIA) to include airborne aircraft on final approach in the conflict alert algorithms. The system uses the ASDE-3 equipment as the display/entry device, requiring no additional displays or entry devices in the tower. Controller entries are not required during normal operations. Entries are required to set the logic at the beginning of each change in runway configuration or operating condition.

The ASTA system to control and manage airport surface taxi traffic will provide the same basic airport surface surveillance system as described above. This system will provide automated tools to monitor/control airport surface traffic taxi flow (in-trail separation at intersections, monitor one-way traffic flow, issue taxi clearance, with route and runway assignment, sequence departure

queues, etc.). It will also provide automatic aircraft status information on departure aircraft for departure sequencing purposes. This system will permit all-weather operations that will reduce ground controller workload, and allows the controller to continue to take advantage of visual observation.

The ASTA will also provide a data link system that will permit direct digital data communications with pilots and aircraft flight management computers. Services provided by the ASTA include delivery of airport traffic situation information to pilots; delivery of aircraft location in relation to an airport map showing runways, taxiways, etc.; and, eventually, delivery of detailed guidance to cockpits to guide aircraft on taxiways to their destination. Additionally, a Tower Workstation will provide automation support for a number of services to aircraft flight crews. Controllers will review and release pre-departure flight plan clearance data and updates for digital delivery to aircraft in the gate area. ATIS messages will be created for both voice broadcast and digital delivery to aircraft on the airport surface via the ASTA, and to aircraft in flight via Mode S Data Link. Wind shear alerts will be processed by the Tower Workstation for digital delivery via Mode S Data Link to aircraft approaching the airport.

4.4 Technology for Planning Initiatives

The following sections describe technologies that will increase capacity and/or reduce delay. These technologies are being developed and used specifically to support FAA planning for future enhancements to the NAS. The National Airspace System Performance Analysis Capability (NASPAC), for example, as well as other computer simulated models, will help in the identification of demand/capacity imbalances in the NAS, and provide a basis for evaluation of proposed solutions to such imbalances. The National Airspace Management Facility (NAMFAC) will provide the means to manage and analyze the air traffic system, as well as provide for effective training of the requisite personnel.

The availability of computer-graphics tools, such as the Sector Design Analysis Tool and the Terminal Airspace Visualization Tool, will allow airspace designers to quickly and effectively develop alternative airspace sectors and procedures, reducing the time and effort required to implement any capacity-enhancing procedures.

4.4.1 Computer Simulation Models

The principal objectives of computer simulation models currently in use and under development are to identify future problems in the National Airspace System caused by demand/capacity imbalances and to construct and evaluate potential solutions. NASPAC relies on computer models and tools, as well as a substantial amount of operational data, including nearly continuous aircraft position, ground delay, and weather data.

A number of prototype models and tools have been developed since the start of the project in the fall of 1987. Principal among them is the simulation model, which traces the progress of individual aircraft through the nationwide airport and airspace network. The simulation model can calculate throughput and delays at individual airports as well as the "ripple" effect of these delays through the system as aircraft traverse their daily itineraries.

Other planning models and tools are being applied in analyses of potential improvements in the National Airspace System to reduce delays and increase throughput. These models and tools are uniquely capable of quantifying the effect of these improvements on the entire system, and include SIMMOD, ADSIM, RDSIM, AIRNET, and others.

4.4.2 National Airspace Management Facility (NAMFAC)

The proposed National Airspace Management Facility (NAMFAC) is intended to provide three major functions to support the goals of the FAA:

- The traffic management function, currently Central Flow Control (CFCF), will ensure the viability of, and provide the national direction and airspace management of, the air traffic control system.
- The modeling and analysis function will include the data bases, personnel, and systems required to provide FAA and selected organizations with tactical recommendations and forecasts based on computer simulation and optimization models, as well as studies and analyses of the air traffic system.
- The management development function will provide a structure to familiarize users with the capabilities of the air traffic control system. Specific areas to be addressed in the curriculum include orientation to national airspace management, recurring training in system management techniques for FAA airspace managers, operational review and critique, and demonstration to the airspace system users of potential system problems identified through modeling efforts.

This facility will house the airspace management organization, the National Weather Service central flow weather service unit (CFWSU), the National Flight Data Center (NFDC), and the National Maintenance Coordination Complex (NMCC). The systems required to support these organizations will also be housed here. These include the current systems: communications, ETMS/ATMS, and the weather service unit equipment; and the future systems: TMP, MWP, sector suites and improved communications system.

The traffic management element of NAMFAC will contain the personnel and systems needed to manage the nation's air traffic system.

The modeling and analysis element of NAMFAC will provide the capabilities required to perform in-depth statistical and analytical studies of the airspace system. These studies will enable the examination of solutions to airspace problems, and the determination of the maximum utilization of the airspace system on a real-time basis as well as during a long-term planning effort. It will also provide simulations and reconstructions to support the training and

refresher activities of the Management Development Facility. The functions required to support this effort include: database management, airspace and rules simulations, and system analysis.

To support the modeling element, current capabilities such as NASPAC will be used and enhanced to provide modeling to support operational planning as well as the longer term analysis capabilities it currently provides to support system planning of the NAS. In order to support airspace planners that will use the NAMFAC modeling capabilities, computer-based airspace design tools will be developed. These tools will be designed to address a range of airspace design problems from relatively localized problems affecting a single sector or terminal area to regional or national scale problems.

4.4.3 Sector Design Analysis Tool

The limiting factor in airspace capacity is usually the amount of aircraft that controllers can handle simultaneously. En route airspace is divided into sectors. Each sector is controlled by a single air traffic control position manned by a radar controller with the help of one or two assistants.

The Sector Design Analysis Tool (SDAT) is an automated tool to be used by airspace designers in the field (at the 20 ARTCCs) to evaluate proposed changes in the design of airspace sectors. This computer model would allow the user to input either the current design or the proposed replacement. It would also allow the user to interactively make changes to the design shown graphically on the computer screen.

The model will allow the user to play recorded traffic data against either the actual design or the proposed replacement. It would also allow the user to modify traffic data interactively in order to evaluate alternative designs under postulated future traffic loadings. The model will compute measures of workload for the specified sector or group of sectors. This will allow designers to obtain a better balance in workload between sectors, reducing delays and staffing requirements. The model will also be useful for facility traffic flow mangers, for it will display cumulative traffic flows under either historic or anticipated future traffic loadings.

The development of the SDAT has been underway for about one year; a proposed preliminary model has been specified. This model concentrates on only one element of controller workload: the critical element of separation assurance (maintaining safe separation between aircraft). Mathematical procedures for extract-

ing the requisite data from FAA data files and computing the expected demand for separation assurance actions have been developed.

4.4.4 Terminal Airspace Visualization Tool

Terminal airspace differs in complexity from en route airspace due to a more varied mix of aircraft and user types, more complicated air traffic rules and procedures, and a wider variation in flight paths. A major redesign of terminal airspace currently requires extensive coordination and effort lasting several months. The purpose of the Terminal Airspace Visualization Tool is to provide computer-based assistance to such a task force that will allow the rapid evaluation of many alternatives, e.g., development of new terminal airspace procedures. An effort is currently underway to develop a prototype to model and support the evaluation of terminal airspace.

The modeling effort has three goals. First, the display of a three-dimensional representation of the airspace on a large computer screen will allow the user/operator to view the airspace from any perspective. The second goal is to provide an easy-to-use interface that permits the user to modify the airspace according to permissible alternatives. The final goal is to develop the capability to quickly evaluate the airspace as displayed to the user in terms of capacity and any other appropriate criteria. A prototype version of the 3-D display is under development at this time.

Chapter 5

Marketplace Solutions

Marketplace solutions to airport capacity are those that rely primarily on competitive, free market influences. They consist of potential new connecting hub airports, reliever airports, and expanded use of existing commercial service airports.

5.1 New Hubs

Hub airports developed since airline deregulation have exhibited more than one of the following characteristics:

- Strong origin/destination (O&D) market
- Good geographic location
- Expandable airport facilities
- Multiple IFR arrival capability
- Strong economy and availability of balanced work force
- Ability to accommodate existing/planned scheduled service fleet

It is reasonable to assume that as flight delays grow at traditional connecting hub airports, airlines will develop new connecting hub airports. Recent examples include Raleigh-Durham and Nashville.

More than two dozen airports have been identified as potential new connecting hub airports.

Potential new hub airports more than 50 miles from forecast delay-problem airports, each with sufficient potential runway capacity to accommodate significant increased airport operations are shown in Figure 5-1.

The potential new connecting hub airports in Figure 5-1 were selected from airports enplaning more than 400,000 passengers in FY 1988 if the airport selected had the potential to permit multiple approach streams during instrument meteorological conditions. The actual development of new connecting hubs will be a function of airline, state, and local community decisions.

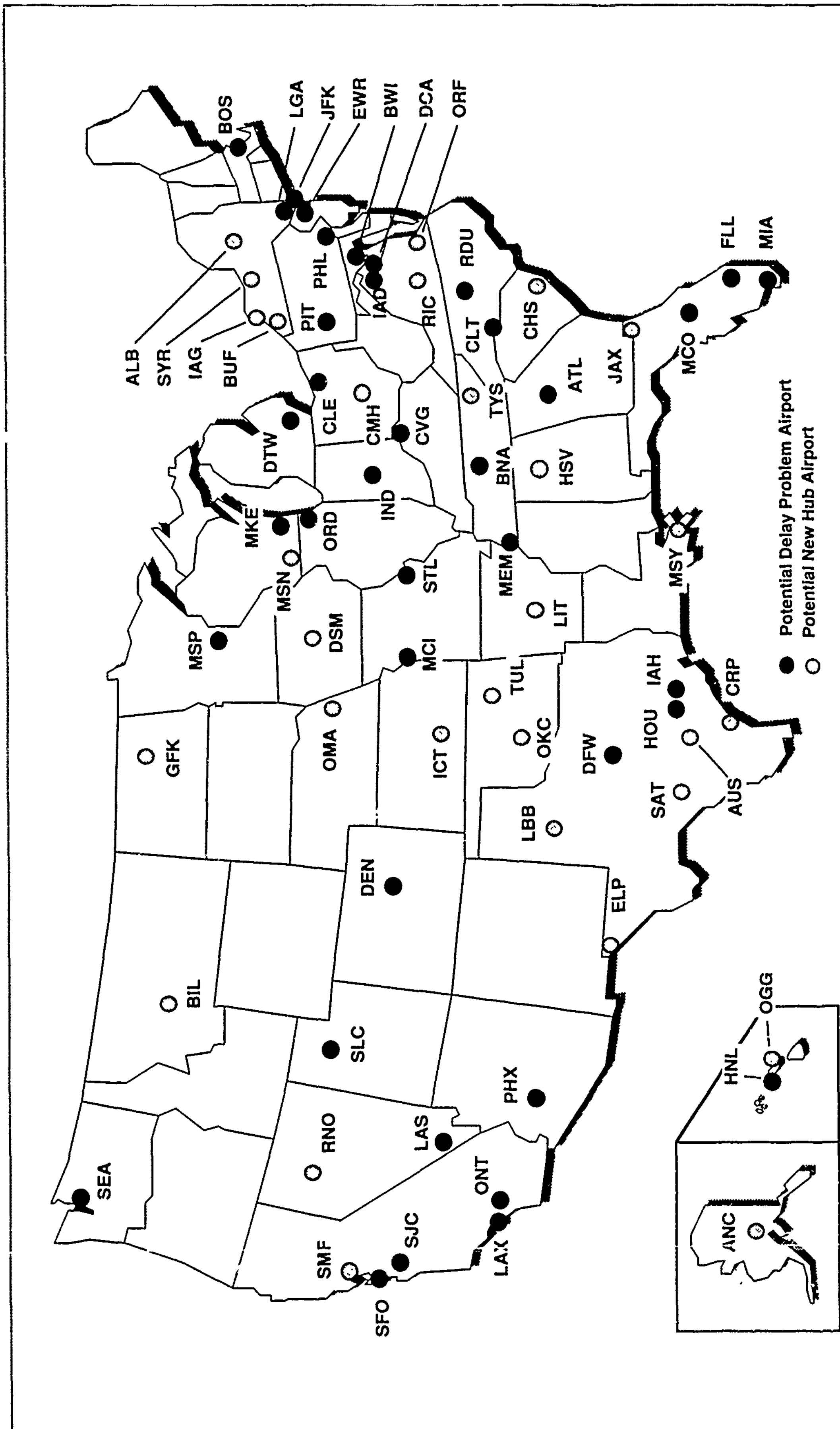


Figure 5-1. Potential New Connecting Hub Airports Having Dual IFR Approaches
(More Than 50 Miles from 1998 Potential Delay Problem Airports)

5.2 New Reliever Airports

Reliever airports play an important role in easing capacity problems at primary airports by spreading aircraft operations over additional airports near these primary airports. In addition, since reliever airports are used mainly by smaller general aviation aircraft, they tend to segregate airport activity by aircraft size. The primary airports serve mostly larger, commercial service aircraft. The segregation of aircraft operations by size increases effective capacity because required time and distance separations are reduced between aircraft of similar size.

The FAA provides assistance for construction and improvements at reliever airports under the Airport Improvement Program. The objective of this assistance are (1) to increase utilization of air carrier airports by building new reliever airports; (2) for existing relievers, to improve facilities and navigational aids; and (3) reduce environmental impacts on neighboring communities.

Reliever airports can be expected to play significant roles in reducing congestion and delay at delay-problem airports, especially those where general aviation constitutes a significant portion (over 25%) of operations.

Of the 41 airports forecast to exceed 20,000 hours annual aircraft delay by 1998 without capacity improvements, 13 have 25% or more general aviation operations.

Table 5-1. Reliever Airports

Forecast Delay-Problem Airports*	Number of Relievers	% of General Aviation Operations (FY 1987)
Atlanta Hartsfield	10	4
Baltimore-Washington	2	22
Boston Logan	6	11
Charlotte Douglas	1	25
Chicago O'Hare	8	4
Cleveland-Hopkins	5	25
Columbus	3	54
Dallas-Fort Worth	13	3
Denver Stapleton	4	8
Detroit Metro Wayne County	10	16
Fort Lauderdale	2	40
Greater Cincinnati	4	11
Honolulu	1	22
Houston Hobby	2	48
Houston Intercontinental	9	17
Indianapolis	5	33
Kansas City	10	7
Los Angeles	6	10
Las Vegas McCarran	1	29
Memphis	5	23
Miami	2	18
Minneapolis-St. Paul	7	19
Nashville	2	36
New York J.F. Kennedy	1	8
New York La Guardia	1	8
Newark	7	7
Ontario	4	27
Orlando	2	14
Philadelphia	11	16
Phoenix-Sky Harbor	6	27
Pittsburgh	6	8
Raleigh-Durham	2	44
Salt Lake City	2	30
San Francisco	4	8
San Jose	5	71
Seattle-Tacoma	8	6
St. Louis-Lambert	12	11
Washington Dulles	2	24
Washington National	5	23

*Assuming no increases in capacity.

Table 5-2. Airports Forecast to Exceed 20,000 Hours of Aircraft Delay in 1998, 25% or More General Aviation Traffic.

Potential Delay-Problem Airport	Percent GA Operations (FY 1987)	Reliever Airport
Phoenix-Sky Harbor International	27	Chandler Municipal Falcon Field Glendale Municipal Phoenix-Deer Valley Municipal Phoenix-Litchfield Municipal Scottsdale Municipal
Raleigh-Durham International	44	Two New Airports Planned
Charlotte-Douglas International	25	Bryant Field
Cleveland-Hopkins International	25	Cuyahoga County Freedom Field Lorain County Regional Lost Nation Strongsville Airpark
Columbus-Port Columbus International	54	Bolton Field Ohio State University Rickenbacker Airport
Fort Lauderdale International	40	Fort Lauderdale Executive North Perry
Houston Hobby	48	Brazoria County Ellington Field
Indianapolis International	33	Indianapolis Downtown Indianapolis Metropolitan Indianapolis Terry Mount Comfort Skyway
Las Vegas McCarran International	29	North Las Vegas Air Terminal
Milwaukee	48	Lawerce J. Timmerman Racine Commercial Waukesha County
Nashville	36	New Airport Planned Smyrna
Ontario	27	Bracket Field Cable Rialto Municipal Riverside Municipal

Table 5-2. Airports Forecast to Exceed 20,000 Hours of Aircraft Delay in 1998, 25% or More General Aviation Traffic (concluded).

Potential Delay-Problem Airport	Percent GA Operations (FY 1987)	Reliever Airport
Salt Lake City International	30	New Airport Planned Salt Lake City Municipal 2
San Jose	71	Two New Airports Planned Palo Alto Airport of Santa Clara Reid-Hilbrew of Santa Clara South County Airport of Santa Clara

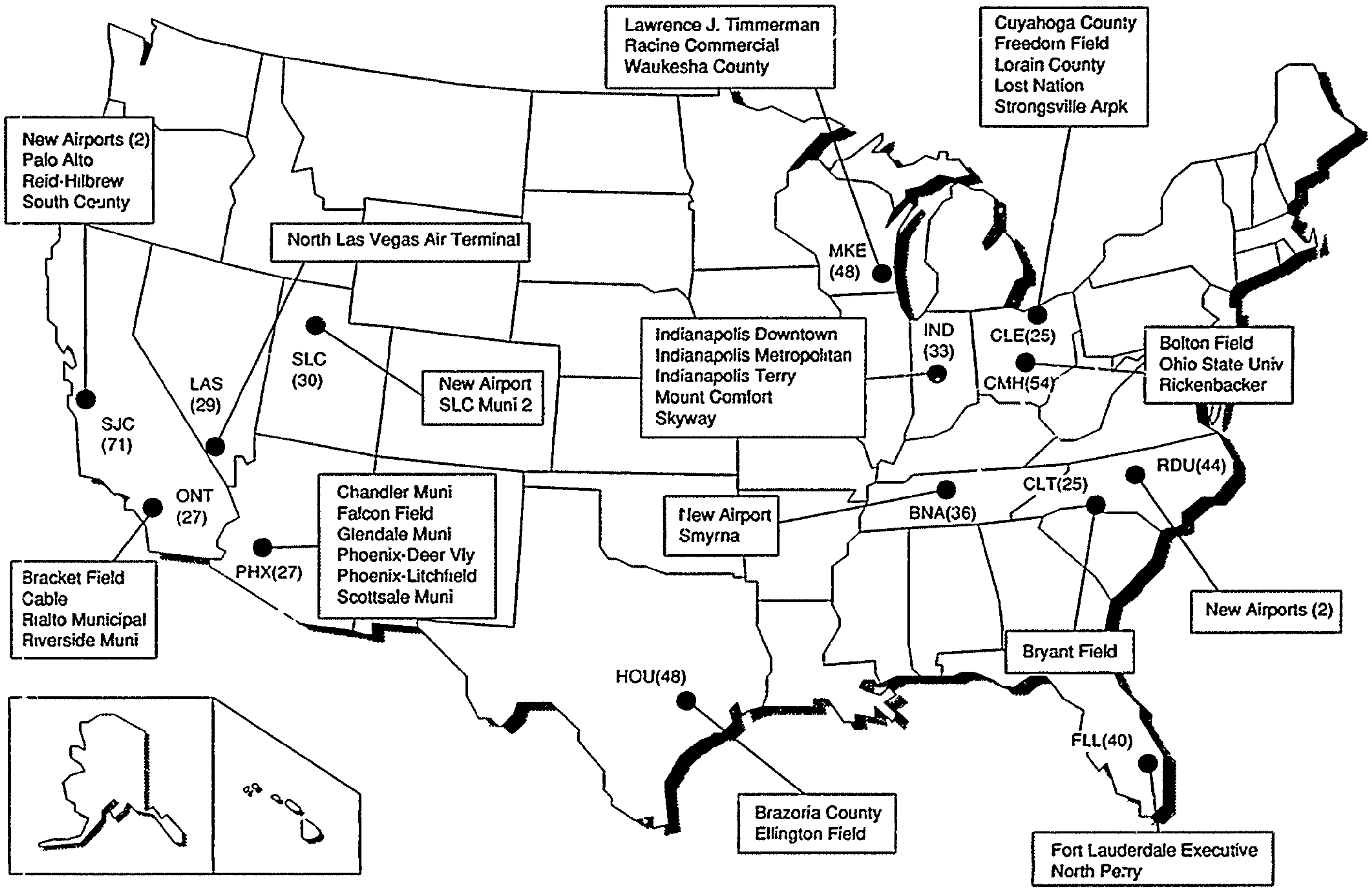


Figure 5-2. Reliever Airports for Delay-Problem Airports with 25% or More General Aviation Operations in 1987

(Number in brackets shows 1987 percent of general aviation operations.)

5.3 Expanded Use of Existing Commercial Service Airports

The development and use of nearby airports, particularly those that provide multiple IFR arrival capability, is a marketplace solution that may tend to reduce delays at forecast delay-problem airports. Of the 41 airports forecast to exceed 20,000 hours of annual aircraft delay in 1998 in the absence of further capacity improvements, 13 have other commercial service airports within 50 miles. As congestion becomes greater at the delay-problem airports, passengers may choose to travel to the alternative airports. For each of these delay-problem airports, traffic diversion would tend to decrease forecast delays.

Of the 41 airports forecast to exceed 20,000 hours of annual aircraft delay in 1998, 13 have other commercial service airports within 50 miles.

Table 5-3. Scheduled Service Airports With Presently Underused Capacities.*

Underused Airport	Potential to Relieve	Distance Between(miles)	Potential Unused Capacity (operations/year)
Manchester, NH	Boston (BOS)	35	37,000
Dallas (DAL), TX	Dallas-Fort Worth (DFW)	8	83,000
Flint, MI	Detroit (DTW)	48	86,000
Toledo, OH	Detroit (DTW)	42	89,000
Houston (HOU), TX	Houston (IAH)	19	39,000
Topeka, KS	Kansas City (MCI)	47	137,000
Palmdale, CA	Los Angeles (LAX)	45	228,000
	Ontario (ONT)	40	
Islip, NY	Newark (EWR)	48	78,000
	New York Kennedy (JFK)	31	
	New York LaGuardia (LGA)	34	
Newburgh, NY	Newark (EWR)	49	94,000
	New York LaGuardia (LGA)	44	
Allentown, PA	Philadelphia (PHL)	50	67,000
Reading, PA	Philadelphia (PHL)	44	82,000
Atlantic City, NJ	Philadelphia (PHL)	39	99,000
Akron-Canton, OH	Cleveland-Hopkins (CLE)	34	54,000
Terre-Haute, IN	Indianapolis (IND)	46	116,000

* Table 5-3 shows the potential unused capacity at airports near the delay-problem airports. The number shown reflects the aggregate unused capacity in thousands of annual operations. The table lists airports that are located within 50 miles of delay-problem airports and that have an "unused capacity." "Unused capacity" is the number of additional aircraft operations that could be accommodated annually by the existing runway system, without having significant delays, although the runways are available, in most instances the existing passenger, baggage, and airport servicing systems would have to be expanded to suppport the increased activity.

Chapter 6

Summary

The Aviation System Capacity Plan is intended as a comprehensive "ground-up" view of aviation system requirements and development. The first step in a problem-solving exercise is problem definition. This plan defines the aviation capacity problem in terms of flight delays rather than dealing with the more abstract "capacity" definition. While it is relatively simple to compute an airport's hourly throughput capacity (the *average* number of flight operations which can be handled in IFR or VFR for a given runway operating configuration), annualizing those numbers is more difficult. The term "congested airport" is a term of art, not science.

This plan states that over 20 major airports each currently experience more than 20,000 hours of annual flight delay. That number is forecast to approximately double in a ten-year time frame in a "do nothing" scenario with no improvements in capacity.

While it is common for demand to exceed hourly capacity at some airports, there are ways of accommodating that demand. First, air traffic management regulates departures and slows down en route traffic, so some delays occur as flights are shifted into times of less congestion. This is a temporary solution because as traffic increases at a given airport, there will be fewer off-peak hours into which flights may be shifted. A survey of ten major airports has shown that hourly flight operation variance is only 7% from 8 a.m. to 7 p.m.

Another demand management technique is to encourage smaller aircraft to use reliever airports. Of the forty forecast delay-problem airports, approximately one-third have in excess of 25% general aviation operations. It might be assumed that there could be significant forecast flight-delay reduction if a percentage of those operations could be shifted to reliever airports. However, several forecast delay-problem airports have fewer than 10% small aircraft operations. It could be argued that those airports are largely "relieved" and further diversion of operations to reliever airports would be of marginal significance in flight delay reduction.

This plan identifies many "underutilized airports" with commercial air service and which are within 50 miles of forecast delay-problem airports. The natural shifting of demand and operations to those airports could result in significant flight delay reduction.

The Aviation System Capacity Plan also identifies potential new connecting hub airports which could serve to decentralize air service at traditional connecting hub airports and reduce flight delays. Economics will dictate if, and how fast, new connecting hub airports are

developed. However, in the 1980's several airline operators chose to rapidly develop underutilized airports to form connecting hubs that improved their networks.

Having identified forecast delay-problem airports, this plan attempts to document planned or technologically feasible capacity development at those airports. This is where the "ground up" view begins. FAA is co-sponsoring airport capacity design teams (task forces) at major airports to assess how airport development and new technology could "optimize" capacity on a site-specific basis. This results in a "good news/bad news" scenario at some airports. For instance, the proposed capacity improvements at Miami International Airport are forecast to reduce potential flight delays by 30-40,000 hours annually at a level of 550,000 annual operations (forecast sometime beyond year 2000). However, since Miami has no new runways planned, residual annual delays are forecast to be 40-50,000 hours with 550,000 operations, two to three times the current level of flight delays. This gives rise to the planning for a new commercial airport in Dade County, currently underway.

The largest capacity gainers at airports are new runways. This plan documents more than 60 new runways or major runway extensions planned or proposed at the top 100 airports. Projects were completed in 1989 at San Jose, Orlando, Ft. Lauderdale, Nashville and Dayton. Significant capacity gains will be achieved by the new runways at Orlando and Nashville. Seventeen runway projects are scheduled for completion in 1990-91, including new runways at Indianapolis and Cincinnati.

Moving from the "ground-up," this plan identifies new terminal airspace procedures which will increase capacity for existing or new runway configurations. Of the top 100 airports, 26 could benefit from improved independent parallel IFR approaches, 21 could benefit from improved dependent parallel approaches, 55 could benefit from non-parallel IFR approaches, and 14 could benefit from triple IFR approaches. Demonstration programs are underway for these new airspace procedures.

Some of the new airspace procedures and airport capacity projects require new technology and new systems and equipment. More than two dozen programs are currently underway in FAA's R,E&D and F&E programs to provide that new technology. This plan outlines the progress of those programs.

Many of the technology programs are designed to reduce the capacity differential between IFR and VFR. The difference in VFR separation standards and IFR separation standards required because of reduced visibility in bad weather, causes 60% to 70% of flight delays. If we can achieve or surpass the capacity levels that we can now achieve visually by the use of new electronic guidance and control equipment, that differential can be improved. If two or three

flight arrival streams can be maintained in IFR, rather than being reduced to two or one arrival stream(s), significant gains in capacity may be achieved.

Some of the technology programs are designed to provide more information to air traffic controllers and pilots with improved visual displays and non-voice communications. Those programs will allow for less new capacity than the programs providing multiple flight arrival and departure streams. The capacity gains are, nevertheless, significant.

Some of the technology programs are designed to improve the efficiency of aircraft movement on the airport surface. Those efficiencies are important, but will not provide quantum leaps in capacity.

Last, some technology programs are designed to "optimize" the aviation system through better planning and improved prediction capability. The gains are marginal in terms of capacity, but significant in terms of delay reduction, since delays increase exponentially as flight operations approach "capacity".

The "ground-up" view encompasses en route airspace. The plan outlines programs designed to increase en route airspace capacity, including Automated En Route Air Traffic Control (AERA), Advanced Traffic Management Systems (ATMS) and others. Major airspace capacity design projects have been accomplished at Boston, Los Angeles, and Dallas/Ft. Worth, and were underway at Chicago, Kansas City, Houston/Austin, and New York in 1989. Oakland, Cleveland, and Washington projects began in 1990. Results or progress reports are included in the plan.

From a "ground up" view, having optimized existing airport capacity, terminal airspace procedures and en route airspace capacity using new technology, the next level is "underutilized airports" and new connecting hub airports for additional aviation system capacity. Beyond that, there is one remaining solution—building new airports. Planning initiatives for new commercial airports are in various stages at Denver, Colorado, Austin, Texas, Atlanta, Georgia, Chicago, Illinois, and other locations.

Aviation's system technology and "optimization" programs hold great promise for new system capacity during the 1990's. Beyond the year 2000, new airports will be required to maintain the same quality of air service available today.

The federal airport grant program is scheduled for Congressional re-authorization in the early 1990's. Historically, federal airport grants represent between 35 and 40 percent of total capital investment for airports, the remainder coming from local and state sources. Total airport development requirements are in excess of $6 billion per year.

System capacity must continue to grow in order to maintain the same level of air service quality. The majority of cities with air service

in 1978 received more frequent service in 1989. Many smaller cities have benefited from the emphasis on hub and spoke airline service in the last decade, receiving more service to connecting hub airports from more than one airline. The expansion of air service networks has increased the number of carriers competing for passengers in a majority of travel markets. In the dozen years since airline deregulation, real air fares have declined. System capacity must continue to grow to allow for airline competition if that trend is to continue.

In conclusion, both the quality and cost of air service is strongly tied to aviation system capacity, and will continue to have favorable trends only if aviation system capacity grows.

Appendix A

Activity Statistics at the Top 100 Airports

Table A-1. Airport Operations and Enplanements [1]

City-Airport	Airport ID	Rank	Enplanements (000s) CY87	CY88	Operations (000s) FY88	FY89
Chicago O'Hare Int'l	ORD	1	26,122	26,597	796	789
Atlanta Hartsfield Int'l	ATL	2	22,649	21,824	783	670
Dallas-Fort Worth Int'l	DFW	3	19,905	21,014	664	694
Los Angeles Int'l	LAX	4	18,970	18,643	632	632
Denver Stapleton Int'l	DEN	5	15,594	14,442	511	468
San Francisco Int'l	SFO	6	13,117	13,348	461	434
New York LaGuardia	LGA	7	11,326	11,322	364	356
Newark Int'l	EWR	8	11,289	10,838	377	377
New York Kennedy Int'l	JFK	9	10,140	10,660	329	337
Boston Logan Int'l	BOS	10	10,255	10,141	445	417
St. Louis Lambert Int'l	STL	11	9,727	9,554	429	425
Miami Int'l	MIA	12	9,342	9,462	358	378
Phoenix Sky Harbor Int'l	PHX	13	8,785	9,455	455	480
Detroit Metro Wayne County	DTW	14	9,254	9,214	380	369
Honolulu Int'l	HNL	15	7,773	8,396	367	406
Pittsburgh Int'l	PIT	16	8,156	8,379	387	379
Minneapolis-St. Paul	MSP	17	8,310	8,171	380	376
Orlando Int'l	MCO	18	7,075	7,473	290	286
Washington National	DCA	19	7,113	7,259	328	316
Houston Intercontinental	IAH	20	6,929	6,872	297	294
Las Vegas McCarran	LAS	21	6,836	6,865	373	378
Seattle Tacoma	SEA	22	6,826	6,826	311	328
Philadelphia Int'l	PHL	23	6,603	6,634	416	383
Charlotte Douglas Int'l	CLT	24	6,021	6,620	405	424
San Diego Lindbergh	SAN	25	4,901	5,181	206	207
Salt Lake City Int'l	SLC	26	4,729	4,730	289	293
Memphis Int'l	MEM	27	5,023	4,533	359	334
Tampa Int'l	TPA	28	4,682	4,495	245	217
Kansas City Int'l	MCI	29	4,481	4,470	226	239
Baltimore-Washington Int'l	BWI	30	4,010	4,370	304	307
Washington Dulles Int'l	IAD	31	4,917	4,327	241	235
Fort Lauderdale Int'l	FLL	32	3,929	3,899	223	217
Houston Hobby	HOU	33	3,930	3,840	261	257
Cleveland Hopkins Int'l	CLE	34	3,103	3,547	248	257
Cincinnati Int'l	CVG	35	3,265	3,543	271	265
Raleigh-Durham Int'l	RDU	36	2,316	3,518	274	273
San Juan Luis Munoz Marin Int'l	SJU	37	2,995	3,264	196	194
Nashville Metro	BNA	38	2,987	3,244	263	276
New Orleans Int'l	MSY	39	3,311	3,200	147	139

1. At the top 100 airports, ranked by 1988 enplanements.

Table A-1. Airport Operations and Enplanements (continued) [2]

City-Airport	Airport ID	Rank	Enplanements (000s) CY87	CY88	Operations (000s) FY88	FY89
Chicago Midway	MDW	40	2,541	3,174	296	316
Portland (OR) Int'l	PDX	41	2,834	2,823	270	268
San Jose Int'l	SJC	42	2,807	2,774	356	318
Dallas Love	DAL	43	2,436	2,475	217	214
Indianapolis Int'l	IND	44	2,273	2,406	219	203
San Antonio Int'l	SAT	45	2,425	2,392	196	204
West Palm Beach Int'l	PBI	46	2,230	2,361	230	234
Ontario Int'l	ONT	47	2,232	2,354	141	143
Windsor Locks Bradleyl Int'l	BDL	48	2,268	2,322	183	174
Santa Ana John Wayne	SNA	49	2,120	2,156	528	534
Dayton Int'l	DAY	50	2,167	2,140	217	205
Albuquerque Int'l	ABQ	51	2,101	2,113	229	231
Kahului	OGG	52	2,032	2,026	167	182
Austin Robert Mueller	AUS	53	1,929	1,922	190	185
Oakland Metro Int'l	OAK	54	1,918	1,826	402	403
Sacramento Metro	SMF	55	1,750	1,792	182	177
Buffalo Int'l	BUF	56	1,729	1,780	130	136
Milwaukee Mitchell Int'l	MKE	57	1,619	1,779	186	197
Columbus Int'l	CMH	58	1,695	1,759	233	233
Oklahoma City Will Rogers World	OKC	59	1,506	1,493	134	137
Norfolk Int'l	ORF	60	1,550	1,492	192	158
Syracuse Hancock Int'l	SYR	61	1,500	1,474	178	180
Fort Myers SW Florida Regional	RSW	62	1,242	1,460	64	57
Burbank	BUR	63	1,524	1,458	221	246
Reno Cannon Int'l	RNO	64	1,584	1,452	164	163
El Paso Int'l	ELP	65	1,329	1,427	193	188
Tucson Int'l	TUS	66	1,526	1,407	239	222
Tulsa Int'l	TUL	67	1,388	1,362	200	187
Jacksonville Int'l	JAX	68	1,407	1,288	155	153
Lihue	LIH	69	1,211	1,264	132	111
Rochester Monroe County	ROC	70	1,254	1,242	213	205
Omaha Eppley	OMA	71	1,073	1,052	156	158
Anchorage	ANC	72	1,006	1,052	206	212
Louisville Standiford	SDF	73	1,034	1.014	159	151
Greensboro Regional	GSO	74	1,026	994	141	143
Birmingham Municipal	BHM	75	912	983	187	187
Providence Green State	PVD	76	864	945	203	200
Little Rock Adams	LIT	77	880	880	147	148
Richmond Int'l	RIC	78	874	851	166	154

2. At the top 100 airports, ranked by 1988 enplanements.

Table A-1. Airport Operations and Enplanements (concluded) [3]

City-Airport	Airport ID	Rank	Enplanements (000s) CY87	CY88	Operations (000s) FY88	FY89
Sarasota-Bradenton	SRQ	79	761	843	169	164
Kailua-Kona Keahole	KOA	80	815	837	57	57
Albany	ALB	81	768	817	181	165
Spokane Int'l	GEG	82	810	744	115	119
Des Moines	DSM	83	739	708	163	160
Charleston (SC) AFB Int'l	CHS	84	680	662	137	130
Colorado Springs Municipal	COS	85	682	641	166	168
Portland (ME) Int'l Jetport	PWM	86	574	613	126	114
Wichita Mid-Continent	ICT	87	655	602	171	167
Midland Int'l	MAF	88	570	602	109	103
Grand Rapids Kent County Int'l	GRR	89	609	597	143	151
Lubbock Int'l	LBB	90	526	583	120	120
Long Beach	LGB	91	605	579	435	462
Hilo General Lyman	ITO	92	537	553	80	93
Knoxville McGhee-Tyson	TYS	93	520	532	164	162
Savannah Int'l	SAV	94	553	531	107	107
Columbia (SC) Metro	CAE	95	571	531	122	116
Boise	BOI	96	541	526	144	160
Islip Long Island MacArthur	ISP	97	495	513	222	209
Harlingen Rio Grande Int'l	HRL	98	478	510	69	63
Greer Greenville-Spartanburg	GSP	99	498	507	68	67
Guam Agana Field	NGM	100	365	487	n/a	n/a
TOTAL			405,934	410,652	25,381	25,080

Sources:

Enplanement data: Airport Activity Statistics of Certificated Route Air Carriers, 1987 and 1988 data.
Operations data: FAA Air Traffic Activity, FY88 and FY89 data.

3. At the top 100 airports, ranked by 1988 enplanements.

Table A-2. Airport Enplanements, 1988 and Forecast 1998 [4]

City-Airport	Airport ID	Rank	Enplanements (000s) CY88	CY98	% Growth
Chicago O'Hare Int'l	ORD	1	28,850	40,835	41.5
Atlanta Hartsfield Int'l	ATL	2	23,537	29,915	27.1
Dallas-Fort Worth Int'l	DFW	3	23,029	32,914	42.9
Los Angeles Int'l	LAX	4	22,179	24,931	12.4
New York Kennedy Int'l	JFK	5	19,415	25,439	31.0
Denver Stapleton Int'l	DEN	6	15,015	30,885	105.7
San Francisco Int'l	SFO	7	14,683	18,049	22.9
Miami Int'l	MIA	8	14,316	17,139	19.7
Boston Logan Int'l	BOS	9	11,802	15,740	33.4
New York LaGuardia	LGA	10	11,790	4,804	25.6
Newark Int'l	EWR	11	11,580	8,996	64.0
Honolulu Int'l	HNL	12	11,081	4,541	31.2
St. Louis Lambert Int'l	STL	13	10,139	5,184	49.8
Detroit Metro Wayne County	DTW	14	10,044	6,168	61.0
Phoenix Sky Harbor Int'l	PHX	15	9,559	7,702	85.2
Pittsburgh Int'l	PIT	16	8,971	6,161	80.1
Minneapolis-St. Paul	MSP	17	8,939	5,299	71.1
Houston Intercontinental	IAH	18	8,142	3,168	61.7
Orlando Int'l	MCO	19	8,122	6,701	105.6
Washington National	DCA	20	7,888	9,025	14.4
Philadelphia Int'l	PHL	21	7,789	2,942	66.2
Seattle Tacoma	SEA	22	7,659	0,977	43.3
Las Vegas McCarran	LAS	23	7,658	4,495	89.3
Charlotte Douglas Int'l	CLT	24	7,613	1,224	47.4
Baltimore-Washington Int'l	BWI	25	5,363	9,499	77.1
San Diego Lindbergh	SAN	26	5,328	8,410	57.8
Salt Lake City Int'l	SLC	27	4,977	9,180	84.4
Memphis Int'l	MEM	28	4,947	8,805	78.0
Washington Dulles Int'l	IAD	29	4,771	8,602	80.3
Kansas City Int'l	MCI	30	4,726	7,243	53.3
Tampa Int'l	TPA	31	4,719	8,006	69.7
Fort Lauderdale Int'l	FLL	32	4,456	7,648	71.6
Cincinnati Int'l	CVG	33	4,069	9,229	126.8
Houston Hobby	HOU	34	3,894	6,627	70.2
Cleveland Hopkins Int'l	CLE	35	3,848	5,216	35.6
Raleigh-Durham Int'l	RDU	36	3,705	9,649	160.4
Nashville Metro	BNA	37	3,447	6,813	97.7
New Orleans Int'l	MSY	38	3,323	5,924	78.3
Chicago Midway	MDW	39	3,266	5,442	66.6

4. At the top 100 airports, ranked by 1988 enplanements.

Table A-2. Airport Enplanements, 1988 and Forecast 1998 (continued) [5]

City-Airport	Airport ID	Rank	Enplanements (000s) FY88	FY98	% Growth
Portland (OR) Int'l	PDX	40	3,019	4,228	40.0
San Jose Int'l	SJC	41	2,818	5,444	93.2
Indianapolis Int'l	IND	42	2,595	3,783	45.8
West Palm Beach Int'l	PBI	43	2,560	4,144	61.9
San Antonio Int'l	SAT	44	2,549	3,834	50.4
Dallas Love	DAL	45	2,481	4,971	100.4
Windsor Locks Bradley Int'l	BDL	46	2,469	3,780	53.1
Dayton Int'l	DAY	47	2,421	3,888	60.6
Ontario Int'l	ONT	48	2,375	5,959	150.9
Albuquerque Int'l	ABQ	49	2,238	3,844	71.8
Santa Ana John Wayne	SNA	50	2,201	3,633	65.1
Syracuse Hancock Int'l	SYR	51	2,186	2,984	36.5
Kahului	OGG	52	2,108	3,379	60.3
San Juan Luis Munoz Marin Int'l	SJU	53	2,039	4,999	145.2
Milwaukee Mitchell Int'l	MKE	54	2,032	4,408	116.9
Oakland Metro Int'l	OAK	55	2,012	3,745	86.1
Austin Robert Mueller	AUS	56	1,925	4,286	122.6
Columbus Int'l	CMH	57	1,864	6,352	240.8
Sacramento Metro	SMF	58	1,839	2,819	53.3
Buffalo Int'l	BUF	59	1,817	2,708	49.0
Norfolk Int'l	ORF	60	1,666	2,645	58.8
Reno Cannon Int'l	RNO	61	1,536	2,458	60.0
Burbank	BUR	62	1,512	2,137	41.3
Oklahoma City Will Rogers World	OKC	63	1,508	2,614	73.3
Fort Myers SW Florida Regional	RSW	64	1,492	3,251	117.9
El Paso Int'l	ELP	65	1,432	2,138	49.3
Anchorage	ANC	66	1,431	2,146	50.0
Tucson Int'l	TUS	67	1,427	2,650	85.7
Jacksonville Int'l	JAX	68	1,399	2,312	65.3
Tulsa Int'l	TUL	69	1,369	2,148	56.9
Rochester Monroe County	ROC	70	1,306	1,968	50.7
Lihue	LIH	71	1,284	1,883	46.7
Louisville Standiford	SDF	72	1,140	1,824	60.0
Omaha Eppley	OMA	73	1,107	1,885	70.3
Providence Green State	PVD	74	1,104	1,678	52.0
Albany	ALB	75	1,059	1,686	59.2
Greensboro Regional	GSO	76	1,005	1,618	61.0
Birmingham Municipal	BHM	77	994	1,487	49.6
Richmond Int'l	RIC	78	944	1,420	50.4

5. At the top 100 airports, ranked by 1988 enplanements.

Table A-2. Airport Enplanements, 1988 and Forecast 1998 (concluded) [6]

City-Airport	Airport ID	Rank	Enplanements (000s) FY88	FY98	% Growth
Little Rock Adams	LIT	79	894	1,314	47.0
Sarasota-Bradenton	SRQ	80	872	1,295	48.5
Kailua-Kona Keahole	KOA	81	853	1,586	85.9
Spokane Int'l	GEG	82	778	1,283	64.9
Des Moines	DSM	83	748	1,108	48.1
Charleston (SC) AFB Int'l	CHS	84	719	1,063	47.8
Portland (ME) Int'l Jetport	PWM	85	690	1,483	114.9
Grand Rapids Kent County Int'l	GRR	86	669	958	43.2
Colorado Springs Municipal	COS	87	656	923	40.7
Wichita Mid-Continent	ICT	88	648	985	52.0
Knoxville McGhee-Tyson	TYS	89	644	988	53.4
Guam Agana Field	GUM	90	627	944	50.6
Islip Long Island MacArthur	ISP	91	618	965	56.1
Midland Int'l	MAF	92	610	907	48.7
Columbia (SC) Metro	CAE	93	587	944	60.8
Lubbock Int'l	LBB	94	584	871	49.1
Greer Greenville-Spartanburg	GSP	95	584	844	44.5
Long Beach	LGB	96	579	1,479	155.4
Hilo General Lyman	ITO	97	557	645	15.8
Boise	BOI	98	547	760	38.9
Savannah Int'l	SAV	99	536	787	46.8
Harlingen Rio Grande Int'l	HRL	100	513	1,015	97.9
TOTAL			459,415	715,810	55.8

Sources:

Enplanement data: Airport Activity Statistics of Certificated Route Air Carriers, 1987 and 1988 data.

6. At the top 100 airports, ranked by 1988 enplanements.

Table A-3. Total Airport Operations, 1988 and Forecast 1998[7]

City-Airport	Airport ID	Rank	Operations (000s) FY88	FY98	% Growth
Chicago O'Hare Int'l	ORD	1	796	822	3.3
Atlanta Hartsfield Int'l	ATL	2	783	912	16.5
Dallas-Fort Worth Int'l	DFW	3	664	988	48.8
Los Angeles Int'l	LAX	4	632	660	4.4
Santa Ana John Wayne	SNA	5	528	653	23.7
Denver Stapleton Int'l	DEN	6	511	789	54.4
San Francisco Int'l	SFO	7	461	491	6.5
Phoenix Sky Harbor Int'l	PHX	8	455	580	27.5
Boston Logan Int'l	BOS	9	445	502	12.8
Long Beach	LGB	10	435	515	18.4
St. Louis Lambert Int'l	STL	11	429	489	14.0
Philadelphia Int'l	PHL	12	416	536	28.8
Charlotte Douglas Int'l	CLT	13	405	512	26.4
Oakland Metro Int'l	OAK	14	402	512	27.4
Pittsburgh Int'l	PIT	15	387	538	39.0
Minneapolis-St. Paul	MSP	16	380	502	32.1
Detroit Metro Wayne County	DTW	17	380	502	32.1
Newark Int'l	EWR	18	377	438	16.2
Las Vegas McCarran	LAS	19	373	517	38.6
Honolulu Int'l	HNL	20	367	475	29.4
New York LaGuardia	LGA	21	363	381	5.0
Memphis Int'l	MEM	22	359	466	29.8
Miami Int'l	MIA	23	358	470	31.3
San Jose Int'l	SJC	24	356	483	35.7
New York Kennedy Int'l	JFK	25	329	370	12.5
Washington National	DCA	26	328	377	14.9
Seattle Tacoma	SEA	27	311	373	19.9
Baltimore-Washington Int'l	BWI	28	304	403	32.6
Houston Intercontinental	IAH	29	297	390	31.3
Chicago Midway	MDW	30	296	384	29.7
Orlando Int'l	MCO	31	290	488	68.3
Salt Lake City Int'l	SLC	32	289	449	55.4
Raleigh-Durham Int'l	RDU	33	274	442	61.3
Cincinnati Int'l	CVG	34	271	480	77.1
Portland (OR) Int'l	PDX	35	270	304	12.6
Nashville Metro	BNA	36	263	351	33.5
Houston Hobby	HOU	37	261	329	26.1
Cleveland Hopkins Int'l	CLE	38	248	280	12.9
Tampa Int'l	TPA	39	245	306	24.9

7. At the top 100 airports, ranked by 1988 enplanements.

Table A-3. Total Airport Operations, 1988 and Forecast 1998 (continued)[8]

City-Airport	Airport ID	Rank	Operations (000s) FY88	FY98	% Growth
Washington Dulles Int'l	IAD	40	241	435	80.5
Tucson Int'l	TUS	41	239	415	73.6
Columbus Int'l	CMH	42	234	290	23.9
West Palm Beach Int'l	PBI	43	230	232	0.9
Albuquerque Int'l	ABQ	44	229	388	69.4
Kansas City Int'l	MCI	45	226	320	41.6
Fort Lauderdale Int'l	FLL	46	223	310	39.0
Islip Long Island MacArthur	ISP	47	222	294	32.4
Burbank	BUR	48	222	288	29.7
Indianapolis Int'l	IND	49	219	277	26.5
Dayton Int'l	DAY	50	217	285	31.3
Dallas Love	DAL	51	217	351	61.8
Rochester Monroe County	ROC	52	213	283	32.9
Anchorage	ANC	53	206	257	24.8
San Diego Lindbergh	SAN	54	206	256	24.3
Providence Green State	PVD	55	203	222	9.4
Tulsa Int'l	TUL	56	200	271	35.5
San Antonio Int'l	SAT	57	196	305	55.6
San Juan Luis Munoz Marinl Int'l	SJU	58	196	224	14.3
El Paso Int'l	ELP	59	193	300	55.4
Norfolk Int'l	ORF	60	192	219	14.1
Austin Robert Mueller	AUS	61	190	340	78.9
Birmingham Municipal	BHM	62	187	256	36.9
Milwaukee Mitchell Int'l	MKE	63	186	227	22.0
Windsor Locks Bradley Int'l	BDL	64	183	307	67.8
Sacramento Metro	SMF	65	182	234	28.6
Albany	ALB	66	181	228	26.0
Syracuse Hancock Int'l	SYR	67	178	243	36.5
Wichita Mid-Continent	ICT	68	171	295	72.5
Sarasota-Bradenton	SRQ	69	169	210	24.3
Kahului	OGG	70	167	233	39.5
Colorado Springs Municipal	COS	71	166	261	57.2
Richmond Int'l	RIC	72	166	241	45.2
Knoxville McGhee-Tyson	TYS	73	164	197	20.1
Reno Cannon Int'l	RNO	74	164	299	82.3
Des Moines	DSM	75	163	228	39.9
Louisville Standiford	SDF	76	159	197	23.9
Omaha Eppley	OMA	77	156	238	52.6
Jacksonville Int'l	JAX	78	155	189	21.9

8. At the top 100 airports, ranked by 1988 enplanements.

Table A-3. Total Airport Operations, FY88 and Forcast 1998 (concluded)[9]

City-Airport	Airport ID	Rank	Operations (000s) FY88	FY98	% Growth
Little Rock Adams	LIT	79	147	255	73.5
New Orleans Int'l	MSY	80	147	221	50.3
Boise	BOI	81	144	306	112.5
Grand Rapids Kent County Int'l	GRR	82	143	176	23.1
Greensboro Regional	GSO	83	141	198	40.4
Ontario Int'l	ONT	84	141	213	51.1
Charleston (SC) AFB Int'l	CHS	85	137	174	27.0
Oklahoma City Will Rogers World	OKC	86	134	222	65.7
Lihue	LIH	87	132	167	26.5
Buffalo Int'l	BUF	88	130	168	29.2
Portland (ME) Int'l Jetport	PWM	89	126	168	33.3
Columbia (SC) Metro	CAE	90	122	188	54.1
Lubbock Int'l	LBB	91	120	177	47.5
Spokane Int'l	GEG	92	115	138	20.0
Midland Int'l	MAF	93	109	174	59.6
Savannah Int'l	SAV	94	107	158	47.7
Hilo General Lyman	ITO	95	80	102	27.5
Guam Agana Field	NGM	96	75	89	18.7
Harlingen Rio Grande Int'l	HRL	97	69	82	18.8
Greer Greenville-Spartanburg	GSP	98	68	94	38.2
Fort Myers SW Florida Regional	RSW	99	64	126	96.9
Kailua-Kona Keahole	KOA	100	57	114	100.0
Total			25,457	33,814	32.8

Source: APO Terminal Area Forecasts

9. At the top 100 airports, ranked by 1988 enplanements.

Table A-4. Growth in Enplanements From 1987 to 1988 [10]

City-Airport	Airport ID	Rank	Enplanements (000s) CY87	CY88	% Growth
Raleigh-Durham Int'l	RDU	1	2,316	3,518	51.9
Milwaukee Mitchell Int'l	MKE	2	1,619	1,779	9.9
Providence Green State	PVD	3	864	945	9.3
Baltimore-Washington Int'l	BWI	4	4,010	4,370	9.0
San Juan Luis Munoz Marin Int'l	SJU	5	2,995	3,264	9.0
Nashville Metro	BNA	6	2,987	3,244	8.7
Cincinnati Int'l	CVG	7	3,265	3,543	8.5
Honolulu Int'l	HNL	8	7,773	8,396	8.0
Birmingham Municipal	BHM	9	912	983	7.8
Phoenix Sky Harbor Int'l	PHX	10	8,785	9,455	7.6
Fort Myers SW Florida Regional	RSW	11	1,242	1,460	7.5
El Paso Int'l	ELP	12	1,329	1,427	7.3
Portland (ME) Int'l Jetport	PWM	13	574	613	6.8
Harlingen Rio Grande Int'l	HRL	14	478	510	6.7
Albany	ALB	15	768	817	6.3
Indianapolis Int'l	IND	16	2,273	2,406	5.9
West Palm Beach Int'l	PBI	17	2,230	2,361	5.9
San Diego Lindbergh	SAN	18	4,901	5,181	5.8
Orlando Int'l	MCO	19	7,075	7,473	5.7
Midland Int'l	MAF	20	570	602	5.7
Dallas-Fort Worth Int'l	DFW	21	19,905	21,014	5.6
Ontario Int'l	ONT	22	2,232	2,354	5.4
New York Kennedy Int'l	JFK	23	10,140	10,660	5.1
Chicago Midway	MDW	24	2,541	3,174	5.0
Anchorage	ANC	25	1,006	1,052	4.5
Cleveland Hopkins Int'l	CLE	26	3,103	3,547	4.3
Lihue	LIH	27	1,211	1,264	4.3
Columbus Int'l	CMH	28	1,695	1,759	3.8
Islip Long Island MacArthur	ISP	29	495	513	3.7
Guam Agana Field	NGM	30	(365)	487	3.4
Buffalo Int'l	BUF	31	1,729	1,780	3.0
Hilo General Lyman	ITO	32	537	553	3.0
Pittsburgh Int'l	PIT	33	8,156	8,379	2.8
Kailua-Kona Keahole	KOA	34	815	837	2.6
Sacramento Metro	SMF	35	1.750	1,792	2.4
Windsor Locks Bradley Int'l	BDL	36	2,268	2,322	2.3
Knoxville McGhee-Tyson	TYS	37	520	532	2.3
Washington National	DCA	38	7,113	7,259	2.0
Greer Greenville-Spartanburg	GSP	39	498	507	1.9

10. Top 100 airports ranked by growth in total enplanements.

Table A-4. Growth in Enplanements From 1987 to 1988 (continued) [11]

City-Airport	Airport ID	Rank	Enplanements (000s) CY87	CY88	% Growth
Chicago O'Hare Int'l	ORD	40	26,122	26,597	1.8
San Francisco Int'l	SFO	41	13,117	13,348	1
Dallas Love	DAL	42	2,436	2,475	1.7
Santa Ana John Wayne	SNA	43	2,120	2,156	1.7
Miami Int'l	MIA	44	9,342	9,462	1.2
Charlotte Douglas Int'l	CLT	45	6,021	6,620	1.0
Lubbock Int'l	LBB	46	526	583	0.8
Sarasota-Bradenton	SRQ	47	761	843	0.7
Albuquerque Int'l	ABQ	48	2,101	2,113	0.5
Las Vegas McCarran	LAS	49	6,836	6,865	0.4
Philadelphia Int'l	PHL	50	6,603	6,634	0.4
Salt Lake City Int'l	SLC	51	4,729	4,730	0
Seattle Tacoma	SEA	52	6,826	6,826	0
Little Rock Adams	LIT	53	880	880	0
New York LaGuardia	LGA	54	11,326	11,322	0
Detroit Metro Wayne County	DTW	55	9,254	9,214	0
Kansas City Int'l	MCI	56	4,481	4,470	-0.2
Kahului	OGG	57	2,032	2,026	-0.2
Portland (OR) Int'l	PDX	58	2,834	2,823	-0.3
Austin Robert Mueller	AUS	59	1,929	1,922	-0.3
Fort Lauderdale Int'l	FLL	60	3,929	3,899	-0.7
Oklahoma City Will Rogers World	OKC	61	1,506	1,493	-0.8
Houston Intercontinental	IAH	62	6,929	6,872	-0.8
Rochester Monroe County	ROC	63	1,254	1,242	-0.9
Omaha Eppley	OMA	64	1,073	1,052	-1.0
Louisville Standiford	SDF	65	1,034	1,014	-1.0
Grand Rapids Kent County Int'l	GRR	66	609	597	-1.0
Boston Logan Int'l	BOS	67	10,255	10,141	-1.1
San Jose Int'l	SJC	68	2,807	2,774	-1.1
Dayton Int'l	DAY	69	2,167	2,140	-1.2
San Antonio Int'l	SAT	70	2,425	2,392	-1.3
Los Angeles Int'l	LAX	71	18,970	18,643	-1.7
St. Louis Lambert Int'l	STL	72	9,727	9,554	-1.7
Minneapolis-St. Paul	MSP	73	8,310	8,171	-1.7
Syracuse Hancock Int'l	SYR	74	1,500	1,474	-1.8
Tulsa Int'l	TUL	75	1,388	1,362	-1.9
Washington Dulles Int'l	IAD	76	4,917	4,327	-2.0
Houston Hobby	HOU	77	3,930	3,840	-2.2
Richmond Int'l	RIC	78	874	851	-2.7

11. Top 100 airports ranked by growth in total enplanements.

Table A-4. Growth in Enplanements From 1987 to 1988 (concluded) [12]

City-Airport	Airport ID	Rank	Enplanements (000s) CY87	CY88	% Growth
Charleston (SC) AFB Int'l	CHS	79	680	662	-2.7
Boise	BOI	80	541	526	-2.8
Greensboro Regional	GSO	81	1,026	994	-3.1
New Orleans Int'l	MSY	82	3,311	3,200	-3.3
Atlanta Hartsfield Int'l	ATL	83	22,649	21,824	-3.6
Norfolk Int'l	ORF	84	1,550	1,492	-3.8
Newark Int'l	EWR	85	11,289	10,838	-4.0
Tampa Int'l	TPA	86	4,682	4,495	-4.0
Savannah Int'l	SAV	87	553	531	-4.0
Des Moines	DSM	88	739	708	-4.1
Long Beach	LGB	89	605	579	-4.2
Burbank	BUR	90	1,524	1,458	-4.3
Oakland Metro Int'l	OAK	91	1,918	1,826	-4.8
Colorado Springs Municipal	COS	92	682	641	-6.0
Columbia (SC) Metro	CAE	93	571	531	-7.0
Denver Stapleton Int'l	DEN	94	15,594	14,442	-7.4
Tucson Int'l	TUS	95	1,526	1,407	-7.8
Wichita Mid-Continent	ICT	96	655	602	-8.0
Spokane Int'l	GEG	97	810	744	-8.1
Reno Cannon Int'l	RNO	98	1,584	1,452	-8.3
Jacksonville Int'l	JAX	99	1,407	1,288	-8.4
Memphis Int'l	MEM	100	5,023	4,533	-9.8
TOTAL			405,934	410,652	1.2

Sources:

Enplanement data: Airport Activity Statistics of Certificated Route Air Carriers, 1987 and 1988 data.

12. Top 100 airports ranked by growth in total enplanements.

Table A-5. Growth in Operations From 1988 to 1989 [13]

City-Airport	Airport ID	Rank	Operations (000s) FY88	FY89	% Growth
Honolulu Int'l	HNL	1	367	406	10.6
Kahului	OGG	2	167	182	9.0
Chicago Midway	MDW	3	296	316	6.8
Long Beach	LGB	4	435	462	6.2
Hilo General Lyman	ITO	5	80	93	6.2
Milwaukee Mitchell Int'l	MKE	6	186	197	6.0
Kansas City Int'l	MCI	7	226	239	5.8
Miami Int'l	MIA	8	358	378	5.6
Seattle Tacoma	SEA	9	311	328	5.5
Phoenix Sky Harbor Int'l	PHX	10	455	480	5.5
Grand Rapids Kent County Int'l	GRR	11	143	151	5.5
Nashville Metro	BNA	12	263	276	5.0
Charlotte Douglas Int'l	CLT	13	405	424	4.7
Buffalo Int'l	BUF	14	130	136	4.7
Dallas-Fort Worth Int'l	DFW	15	664	694	4.5
Cleveland Hopkins Int'l	CLE	16	248	257	3.7
Spokane Int'l	GEG	17	115	119	3.5
Anchorage	ANC	18	206	212	3.0
New York Kennedy Int'l	JFK	19	329	337	2.4
Oklahoma City Will Rogers World	OKC	20	134	137	2.2
West Palm Beach Int'l	PBI	21	230	234	1.8
Salt Lake City Int'l	SLC	22	289	293	1.4
Ontario Int'l	ONT	23	141	143	1.4
Greensboro Regional	GSO	24	141	143	1.4
Las Vegas McCarran	LAS	25	373	378	1.3
Burbank	BU	26	221	246	1.3
Omaha Eppley	OMA	27	156	158	1.2
Colorado Springs Municipal	COS	28	166	168	1.2
Syracuse Hancock Int'l	SYR	29	178	180	1.1
Santa Ana John Wayne	SNA	30	528	534	1.1
Boise	BOI	31	144	160	1.1
Baltimore-Washington Int'l	BWI	32	304	307	1.0
Albuquerque Int'l	ABQ	33	229	231	0.8
Little Rock Adams	LIT	34	147	148	0.6
San Diego Lindbergh	SAN	35	206	207	0.5
Oakland Metro Int'l	OAK	36	402	403	0.2
Savannah Int'l	SAV	37	107	107	0
San Antonio Int'l	SAT	38	196	204	0
Newark Int'l	EWR	39	377	377	0

13. Top 100 airports ranked by growth in total operations.

Table A-5. Growth in Operations From 1988 to 1989 (continued) [14]

City-Airport	Airport ID	Rank	Operations (000s) FY88	FY89	% Growth
Lubbock Int'l	LBB	40	120	120	0
Los Angeles Int'l	LAX	41	632	632	0
Kailua-Kona Keahole	KOA	42	57	57	0
Columbus Int'l	CMH	43	233	233	0
Birmingham Municipal	BHM	44	187	187	0
Raleigh-Durham Int'l	RDU	45	274	273	-0.4
San Jose Int'l	SJC	46	356	318	-0.6
Reno Cannon Int'l	RNO	47	164	163	-0.6
Portland (OR) Int'l	PDX	48	270	268	-0.7
St. Louis Lambert Int'l	STL	49	429	425	-0.9
Fort Myers SW Florida Regional	RSW	50	64	57	-0.9
Chicago O'Hare Int'l	ORD	51	796	789	-0.9
San Juan Luis Munoz Marin Int'l	SJU	52	196	194	-1.0
Houston Intercontinental	IAH	53	297	294	-1.0
Minneapolis-St. Paul	MSP	54	380	376	-1.1
Knoxville McGhee-Tyson	TYS	55	164	162	-1.2
Jacksonville Int'l	JAX	56	155	153	-1.2
Dallas Love	DAL	57	217	214	-1.3
Providence Green State	PVD	58	203	200	-1.4
Orlando Int'l	MCO	59	290	286	-1.4
Greer Greenville-Spartanburg	GSP	60	68	67	-1.4
Houston Hobby	HOU	61	261	257	-1.5
Des Moines	DSM	62	163	160	-1.9
Pittsburgh Int'l	PIT	63	387	379	-2.1
New York LaGuardia	LGA	64	364	356	-2.2
Cincinnati Int'l	CVG	65	271	265	-2.2
Wichita Mid-Continent	ICT	66	171	167	-2.3
Washington Dulles Int'l	IAD	67	241	235	-2.5
El Paso Int'l	ELP	68	193	188	-2.5
Sacramento Metro	SMF	69	182	177	-2.7
Fort Lauderdale Int'l	FLL	70	223	217	-2.7
Austin Robert Mueller	AUS	71	190	185	-2.7
Detroit Metro Wayne County	DTW	72	380	369	-2.9
Sarasota-Bradenton	SRQ	73	169	164	-3.0
Washington National	DCA	74	328	316	-3.7
Rochester Monroe County	ROC	75	213	205	-3.8
Windsor Locks Bradley Int'l	BDL	76	183	174	-5.0
Louisville Standiford	SDF	77	159	151	-5.0
Columbia (SC) Metro	CAE	78	122	116	-5.0

14. Top 100 airports ranked by growth in total operations.

Table A-5. Growth in Operations From 1988 to 1989 (concluded) [15]

City-Airport	Airport ID	Rank	Operations (000s) FY88	FY89	% Growth
Charleston (SC) AFB Int'l	CHS	79	137	130	-5.1
New Orleans Int'l	MSY	80	147	139	-5.4
Midland Int'l	MAF	81	109	103	-5.5
Dayton Int'l	DAY	82	217	205	-5.5
San Francisco Int'l	SFO	83	461	434	-5.9
Islip Long Island MacArthur	ISP	84	222	209	-5.9
Lihue	LIH	85	132	111	-6.0
Boston Logan Int'l	BOS	86	445	417	-6.3
Tulsa Int'l	TUL	87	200	187	-6.5
Memphis Int'l	MEM	88	359	334	-7.0
Tucson Int'l	TUS	89	239	222	-7.1
Richmond Int'l	RIC	90	166	154	-7.2
Indianapolis Int'l	IND	91	219	203	-7.3
Norfolk Int'l	ORF	92	192	158	-7.8
Philadelphia Int'l	PHL	93	416	383	-7.9
Denver Stapleton Int'l	DEN	94	511	468	-8.4
Harlingen Rio Grande Int'l	HRL	95	69	63	-8.7
Albany	ALB	96	181	165	-8.9
Portland (ME) Int'l Jetport	PWM	97	126	114	-9.5
Tampa Int'l	TPA	98	245	217	-11.4
Atlanta Hartsfield Int'l	ATL	99	783	670	-14.4
Guam Agana Field	NGM	100			
TOTAL			25,381	25,080	-1.2

Sources:

Enplanement data: Airport Activity Statistics of Certificated Route Air Carriers, 1988 and 1989 data.
Operatins data: FAA Air Traffic Activity FY1988 and FY1989 data.

15. Top 100 airports ranked by growth in total operations.

Table A-6. Growth in Operations and Enplanements [16]

City-Airport	Airport ID		% Growth in Enplanements CY87 to CY88	% Growth in Operations FY88 to FY89
Albany	ALB	1	6.3	-8.9
Albuquerque Int'l	ABQ	2	0.5	0.8
Anchorage	ANC	3	4.5	3.0
Atlanta Hartsfield Int'l	ATL	4	-3.6	-14.4
Austin Robert Mueller	AUS	5	-0.3	-2.7
Baltimore-Washington Int'l	BWI	6	9.0	1.0
Birmingham Municipal	BHM	7	7.8	0
Boise	BOI	8	-2.8	1.1
Boston Logan Int'l	BOS	9	-1.1	-6.3
Buffalo Int'l	BUF	10	3.0	4.7
Burbank	BUR	11	-4.3	1.3
Charleston (SC) AFB Int'l	CHS	12	-2.7	-5.1
Charlotte Douglas Int'l	CLT	13	1.0	4.7
Chicago Midway	MDW	14	5.0	6.8
Chicago O'Hare Int'l	ORD	15	1.8	-0.9
Cincinnati Int'l	CVG	16	8.5	-2.2
Cleveland Hopkins Int'l	CLE	17	4.3	3.7
Colorado Springs Municipal	COS	18	-6.0	1.2
Columbia (SC) Metro	CAE	19	-7.0	-5.0
Columbus Int'l	CMH	20	3.8	0
Dallas Love	DAL	21	1.7	-1.3
Dallas-Fort Worth Int'l	DFW	22	5.6	4.5
Dayton Int'l	DAY	23	-1.2	-5.5
Denver Stapleton Int'l	DEN	24	-7.4	-8.4
Des Moines	DSM	25	-4.1	-1.9
Detroit Metro Wayne County	DTW	26	0	-2.9
El Paso Int'l	ELP	27	7.3	-2.5
Fort Lauderdale Int'l	FLL	28	-0.7	-2.7
Fort Myers SW Florida Regional	RSW	29	7.5	-0.9
Grand Rapids Kent County Int'l	GRR	30	-1.0	5.5
Greensboro Regional	GSO	31	-3.1	1.4
Greer Greenville-Spartanburg	GSP	32	1.9	-1.4
Guam Agana Field	NGM	33	3.4	
Harlingen Rio Grande Int'l	HRL	34	6.7	-8.7
Hilo General Lyman	ITO	35	3.0	6.2
Honolulu Int'l	HNL	36	8.0	10.6
Houston Hobby	HOU	37	-2.2	-1.5
Houston Intercontinental	IAH	38	-0.8	-1.0
Indianapolis Int'l	IND	39	5.9	-7.3

16. At the top 100 airports, in alphabetical order.

Table A-6. Growth in Operations and Enplanements (continued) [17]

City-Airport	Airport ID		% Growth in Enplanements CY87 to CY88	% Growth in Operations FY88 to FY89
Islip Long Island MacArthur	ISP	40	3.7	-5.9
Jacksonville Int'l	JAX	41	-8.4	-1.2
Kahului	OGG	42	-0.2	9.0
Kailua-Kona Keahole	KOA	43	2.6	0
Kansas City Int'l	MCI	44	-0.2	5.8
Knoxville McGhee-Tyson	TYS	45	2.3	-1.2
Las Vegas McCarran	LAS	46	0.4	1.3
Lihue	LIH	47	4.3	-6.0
Little Rock Adams	LIT	48	0	0.6
Long Beach	LGB	49	-4.2	6.2
Los Angeles Int'l	LAX	50	-1.7	0
Louisville Standiford	SDF	51	-1.0	-5.0
Lubbock Int'l	LBB	52	0.8	0
Memphis Int'l	MEM	53	-9.8	-7.0
Miami Int'l	MIA	54	1.2	5.6
Midland Int'l	MAF	55	5.7	-5.5
Milwaukee Mitchell Int'l	MKE	56	9.9	6.0
Minneapolis-St. Paul	MSP	57	-1.7	-1.1
Nashville Metro	BNA	58	8.7	5.0
New Orleans Int'l	MSY	59	-3.3	-5.4
New York Kennedy Int'l	JFK	60	5.1	2.4
New York LaGuardia	LGA	61	0	-2.2
Newark Int'l	EWR	62	-4.0	0
Norfolk Int'l	ORF	63	-3.8	-7.8
Oakland Metro Int'l	OAK	64	-4.8	0.2
Oklahoma City Will Rogers World	OKC	65	-0.8	2.2
Omaha Eppley	OMA	66	-1.0	1.2
Ontario Int'l	ONT	67	5.4	1.4
Orlando Int'l	MCO	68	5.7	-1.4
Philadelphia Int'l	PHL	69	0.4	-7.9
Phoenix Sky Harbor Int'l	PHX	70	7.6	5.5
Pittsburgh Int'l	PIT	71	2.8	-2.1
Portland (ME) Int'l Jetport	PWM	72	6.8	-9.5
Portland (OR) Int'l	PDX	73	-0.3	-0.7
Providence Green State	PVD	74	9.3	-1.4
Raleigh-Durham Int'l	RDU	75	51.9	-0.4
Reno Cannon Int'l	RNO	76	-8.3	-0.6
Richmond Int'l	RIC	77	-2.7	-7.2
Rochester Monroe County	ROC	78	-0.9	-3.8

17. At the top 100 airports, in alphabetical order.

Table A-6. Growth in Operations and Enplanements (concluded) [18]

City-Airport	Airport ID		% Growth in Enplanements CY87 to CY88	% Growth in Operations FY88 to FY89
Sacramento Metro	SMF	79	2.4	-2.7
Salt Lake City Int'l	SLC	80	0	1.4
San Antonio Int'l	SAT	81	-1.3	0
San Diego Lindbergh	SAN	82	5.8	0.5
San Francisco Int'l	SFO	83	1.8	-5.9
San Jose Int'l	SJC	84	-1.1	-0.6
San Juan Luis Munoz Marin Int'l	SJU	85	9.0	-1.0
Santa Ana John Wayne	SNA	86	1.7	1.1
Sarasota-Bradenton	SRQ	87	0.7	-3.0
Savannah Int'l	SAV	88	-4.0	0
Seattle Tacoma	SEA	89	0	5.5
Spokane Int'l	GEG	90	-8.1	3.5
St. Louis Lambert Int'l	STL	91	-1.7	-0.9
Syracuse Hancock Int'l	SYR	92	-1.8	1.1
Tampa Int'l	TPA	93	-4.0	-11.4
Tucson Int'l	TUS	94	-7.8	-7.1
Tulsa Int'l	TUL	95	-1.9	-6.5
Washington Dulles Int'l	IAD	96	-2.0	-2.5
Washington National	DCA	97	2.0	-3.7
West Palm Beach Int'l	PBI	98	5.9	1.8
Wichita Mid-Continent	ICT	99	-8.0	-2.3
Windsor Locks Bradley Int'l	BDL	100	2.3	-5.0

Sources:

Enplanement data: Airport Activity Statistics of Certificated Route Air Carriers, 1987 and 1988 data.

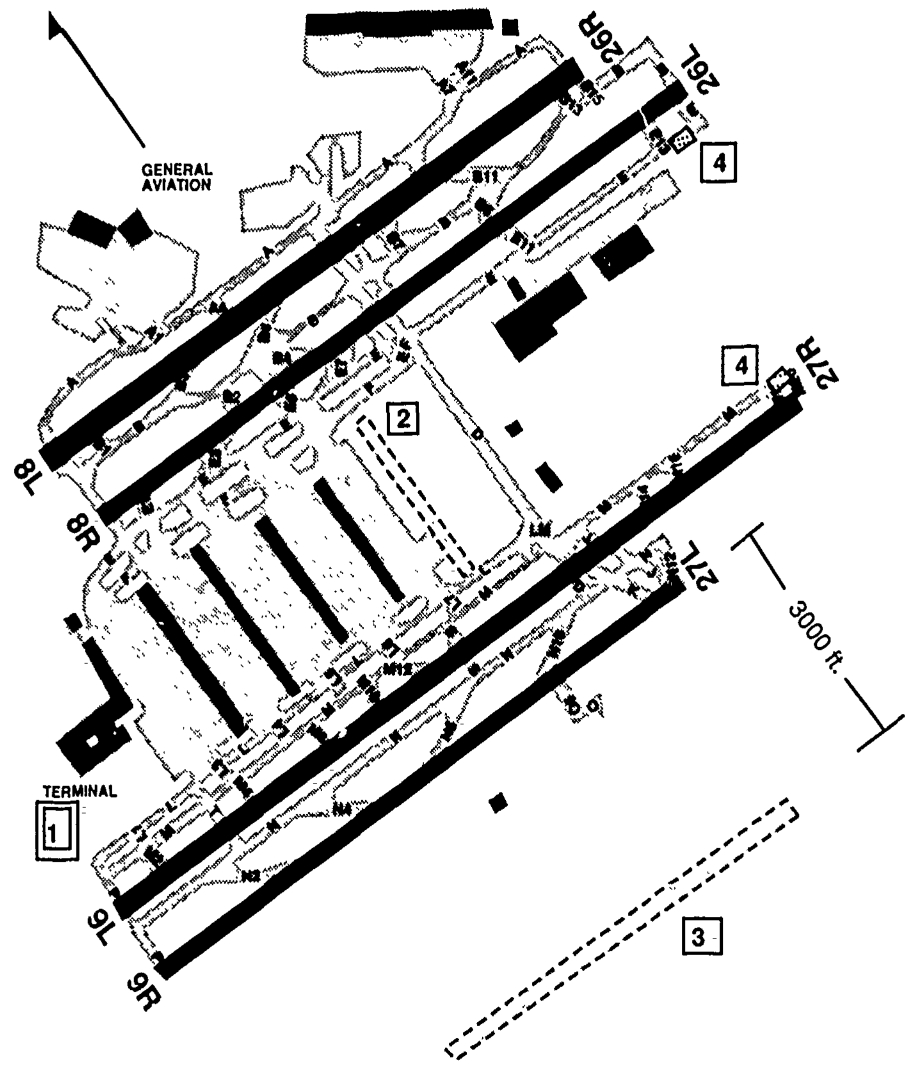
Operations data: FAA Air Traffic Activity FY1988 and FY1989 data.

18. At the top 100 airports, in alphabetical order.

Appendix B

Airport Capacity Design Team Project Summaries [1]

1. Some of the airport capacity design teams are currently underway and project recomendations are tentative.



= recommended improvement

= completed improvement

(5000 FT.)

ATLANTA - HARTSFIELD INTERNATIONAL AIRPORT

REVISED 7-26-90

Atlanta-Hartsfield International Airport
Airport Capacity Design Team Project Summary

Recommended Improvements

Airfield Improvements

1. International concourse
2. Fifth concourse
3. Commuter/GA terminal and runway complex south of R/W 9R/27L
4. Three hold pads/bypass taxiways at end of departure runways
5. Taxiway C parallel to the west of taxiway D (not pictured)
6. Angled exits for commuter aircraft; widen fillets at exits to facilitate their use in either direction (not pictured)

Facilities and Equipment Improvements

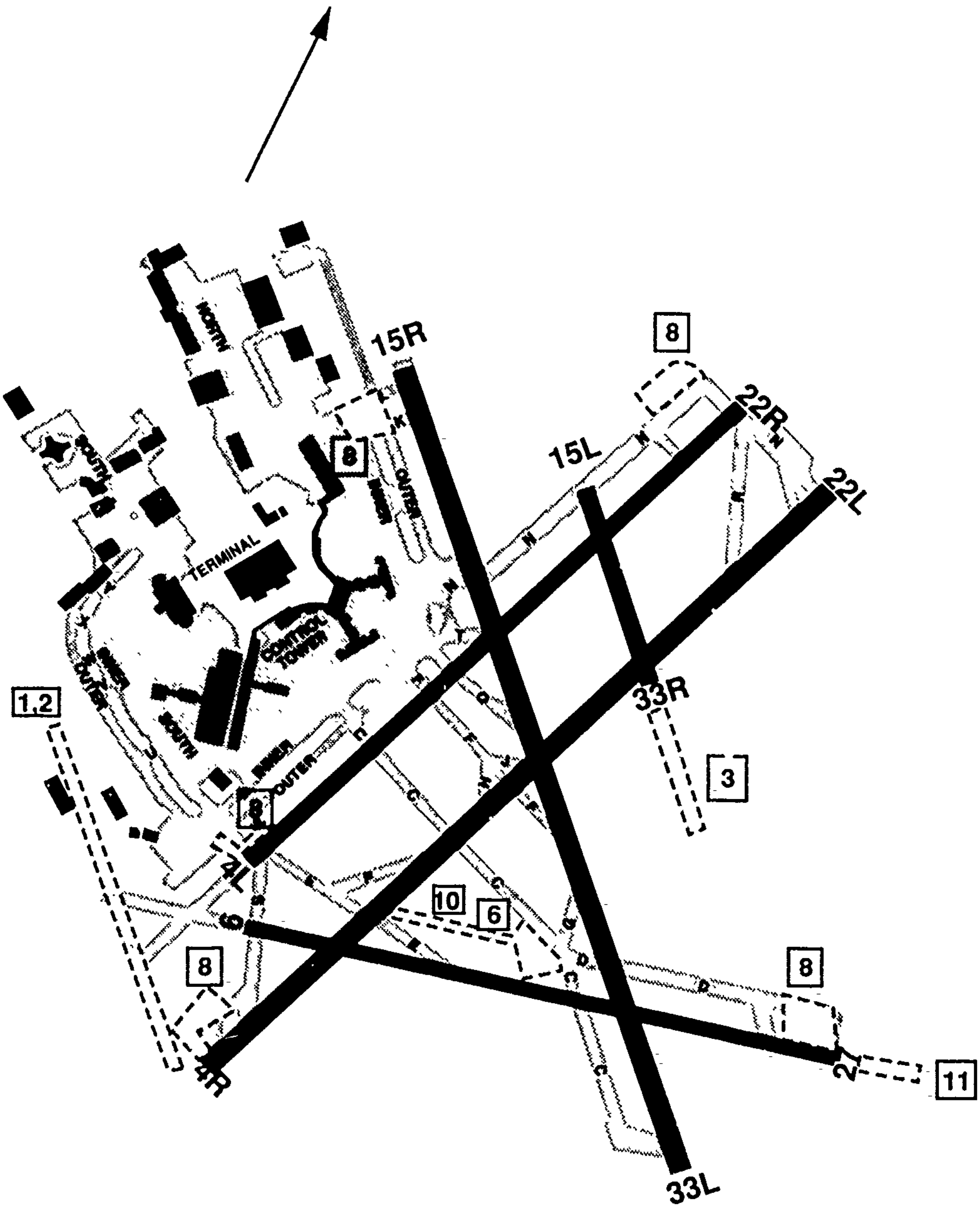
7. Expedite development and installation of wake vortex forecasting and avoidance systems
8. Upgrade NAVAIDS and approach lights on R/W 26R and 27L to Category II
9. Update terminal approach radar
10. Upgrade RVR system to CAT IIIB and ICAO standards
11. Install ASDE III with tracking
12. Install touchdown zone lights on R/W 27L

Operational Improvements

13. Reduce arrival separations to 2.5 nm
14. Enhance traffic management procedures

User Improvements

15. Depeak airline schedules within the hour



= potential improvement being evaluated

= completed improvement

(5000 FT.)

BOSTON-LOGAN INTERNATIONAL AIRPORT

12/22/89

Boston-Logan International Airport
Airport Capacity Design Team Project Summary

Potential Improvements Being Evaluated

Airfield Improvements

1. New Runway 14/32 (4300') With a Fully Instrumented Parallel Approach Unidirectional Departure 14 and Arrival 32
2. New Runway 14/32 (4300') With a Fully Instrumented Parallel Approach Bidirectional
3. Extend Runway 15L/33R to Approximately 3,500' and Add New Parallel Taxiway
   a. Combine Improvements 1 and 3
   b. Combine Improvements 2 and 3
4. New Parallel Taxiway Between Runway 4L/22R and 4R/22L (Not Pictured)
5. New South Exit Parallel Taxiway for Runway 27 (Not Pictured)
6. Add Fillets at Intersections of Taxiways D and C with Runway 15R/33L
7. Extend and Recover Runway 9/27 to the West 400' (Required for Improvement 24)
8. Add Staging Areas at End of Runway 15R/33L, 27, 4R, 22R and at Intersection of Taxiway G of Runway 33L
10. Extend Taxiway D to Runway 4R/22L
11. Extend Runway 27 125' East (to Allow Hold Short Ops.) (Required for Improvement 23)

Facility and Equipment Improvements

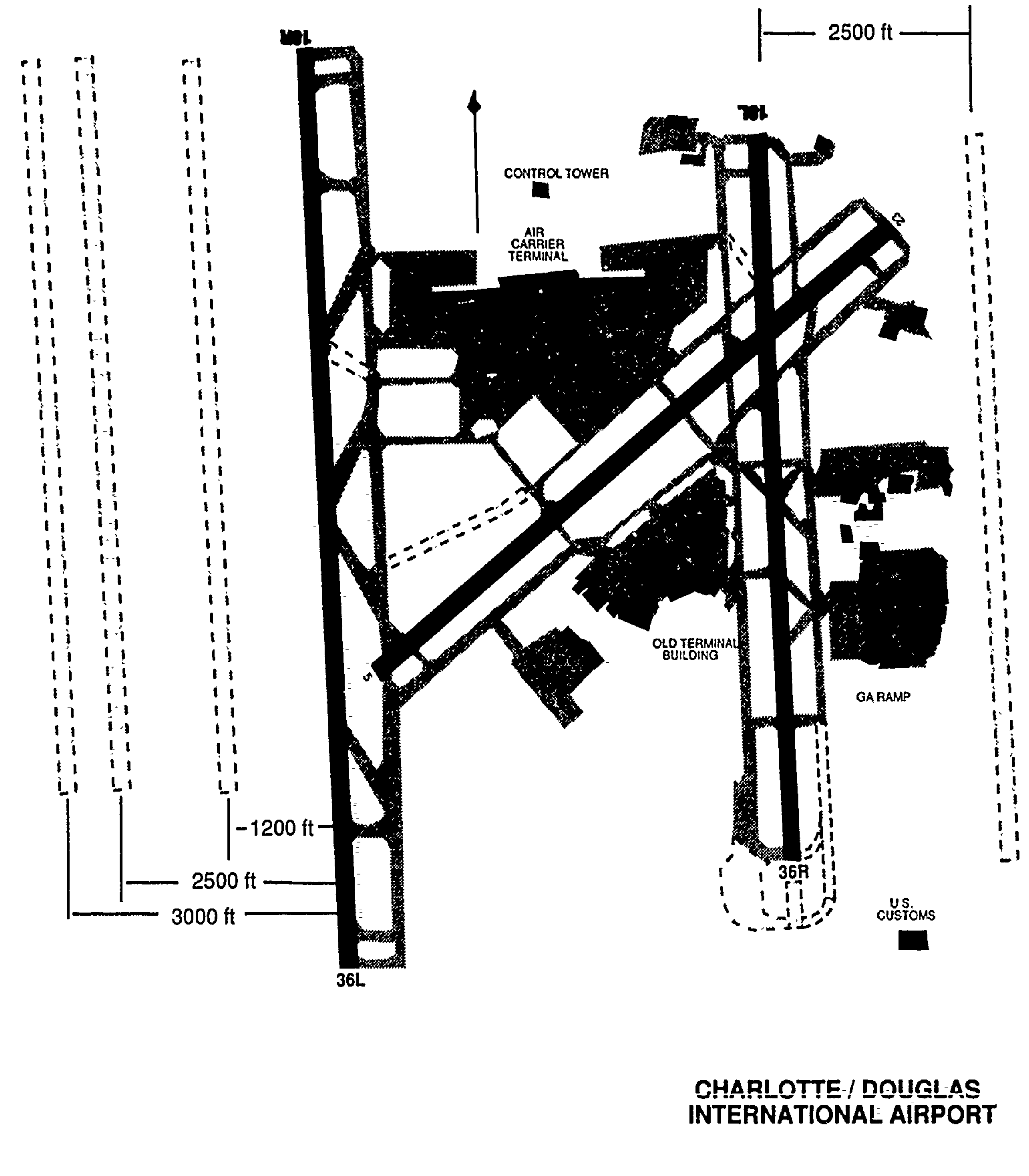
12. CAT II/III ILS on 15R and/or 22L and/or 33L
13. Benefit of Microwave Landing System (Dual Glide Slopes)
14. Simultaneous Approaches to the 4's and 22's in Less Than VFR-V Conditions

Operational Improvements

15. Benefit of WVAS and VAS
16. Modify ATC Procedures to Allow Simultaneous Operations to Runway 27 and 22L or Runway 4L and 33L Under IFR Conditions
17. Removal of Noise Restrictions on 4L Departure and 212R Arrival
    a. Remove Noise Restriction and Extend Runway 4L and New Taxiway B
18. Impact of Fleet Mix Changes
19. Reduce Minimums to 250 and 3/4 on 22L CAT I
20. Side Step Approaches From Runway 4R to Runway 4L
21. Fan Headings for Runway 22L and 22R Departure Operations
22. Separate GA and Commuters From Commercial Jet Traffic
23. Use of Runway 27 by Jet Aircraft to Hold Short of 22L
24. Use of Runway 9 by Class 3 and 4 to Hold Short of 15R
25. Use of Hold Short Procedures Under Wet Conditions of Landing Distances 6000' or greater for Turbojet Aircraft on Runway's 15R-Hold Short of 9, 22L-Hold Short of 27, 33L-Hold Short of 4L

User Improvements

26. Improve Metering, Spacing and Segregate Heavy Jets
27. Improve or Redistribute Airline Schedules Within Hour



CHARLOTTE / DOUGLAS INTERNATIONAL AIRPORT

REVISED 5/25/90

Charlotte/Douglas International Airport
Airport Capacity Design Team Project Summary

Potential Improvements Being Evaluated

Airfield Improvements

1. High Speed Exit C7 off 36R
2. High Speed Exit E7 off 18R for Commuters
3. Extension of Taxiway M, Parallel to 5/23
4. Build 3rd Parallel Runway, 18W/36W, West of 18R/36L, 8000' Long, CAT II/III Precision Approach
   a. 1200' West — No arrivals on 18R (Scheduled for 1995)
   b. 2500' West, Staggered Approach in IFR
   c. >3000' West, 2 Independent & 1 Dependent Parallel Approaches
   d. >3000' West, 3 Independent Parallel Approaches
5. Build 4th Parallel Runway, 18E/36E, with LDA Staggered Approach 2500' East of 18L/36R — Relocate highway
6. Extend 36R South 1000', Add Holding Pad, Extend Taxiways C & D to Approach End of 36R
7. Extend 36R Farther South, Displace Rwy 5 Threshold, Add Holding Pad, Extend Taxiways C & D (No hold shorts on 36R when wet. Depart on Runway 5)
8. Shift 18L/36R South So It Does Not Intersect Runway 5/23, Add Holding Pad, Extend Taxiways C & D (Turn 36R departures onto 5/23 heading — Problem with new bldg)
9. Extend Taxiway D to Approach End of Existing 36R (So GA will not have to cross an active runway) CONSIDER THIS ONLY IF 36R IS NOT EXTENDED SOUTH
10. Build High Speed Exits off Runway 18L

11a. Build High Speed Exits off Runway 23

12. Relocate ATC Tower to the South — Improve airport visibility, Reduce communications between ground controllers & pilots

Facilities and Equipment Improvements

13. CAT I ILS on 18L (With 200' displaced threshold) (Opens 9/90)
    a. With 3.0 NM longitudinal spacing
    b. With 2.5 NM longitudinal spacing (Need Angled Exits)
14. CAT I ILS on 23 (Allow SCIAs down to lower minimums)
    a. With 3.0 NM longitudinal spacing
    b. With 2.5 NM longitudinal spacing (Need Angled Exits)
15. CAT II/III ILS on 18R (With 2.5 NM longitudinal spacing)
16. CAT II/III ILS on 18L & 36R
    a. With 3.0 NM long. spacing on 18L & 2.5 NM spacing on 36R
    b. With 2.5 NM on 18L & 36R (Need angled exits on 18L)
17. ASDE (Airport Surface Detection Equipment) (To tell when arrivals exit a runway when weather is very poor)
18. New VOR 40 Miles Northwest of CLT at Hickory (Overflight relief cleans up airspace & helps controllers)
19. Expand TRACON ARTS IIIA, Add 2 Radar Scopes (1 for TMS) & Upgrade Communications
20. FDAD ARTS (Full Digital Automated Display)

continued on next page

Charlotte/Douglass International Airport
Airport Capacity Design Team Project Summary (concluded)

Operational (Procedures) Improvements

21. VOR/DME Approach to Runway 23 (In the works)
22. Waiver to Continue North Operation with Wet Runways when Tailwind Component is 6 or 7 knots.
23. Increase ATC Staffing (To handle higher demands)
24. Increase Satellite Control Positions (2 or 3) for Departures, e.g. Put Small-slow aircraft onto satellite stream to take them out of departure stream. Use 4 departure streams instead of today's 2. Reduce impact of Center's 10NM intrail restriction.

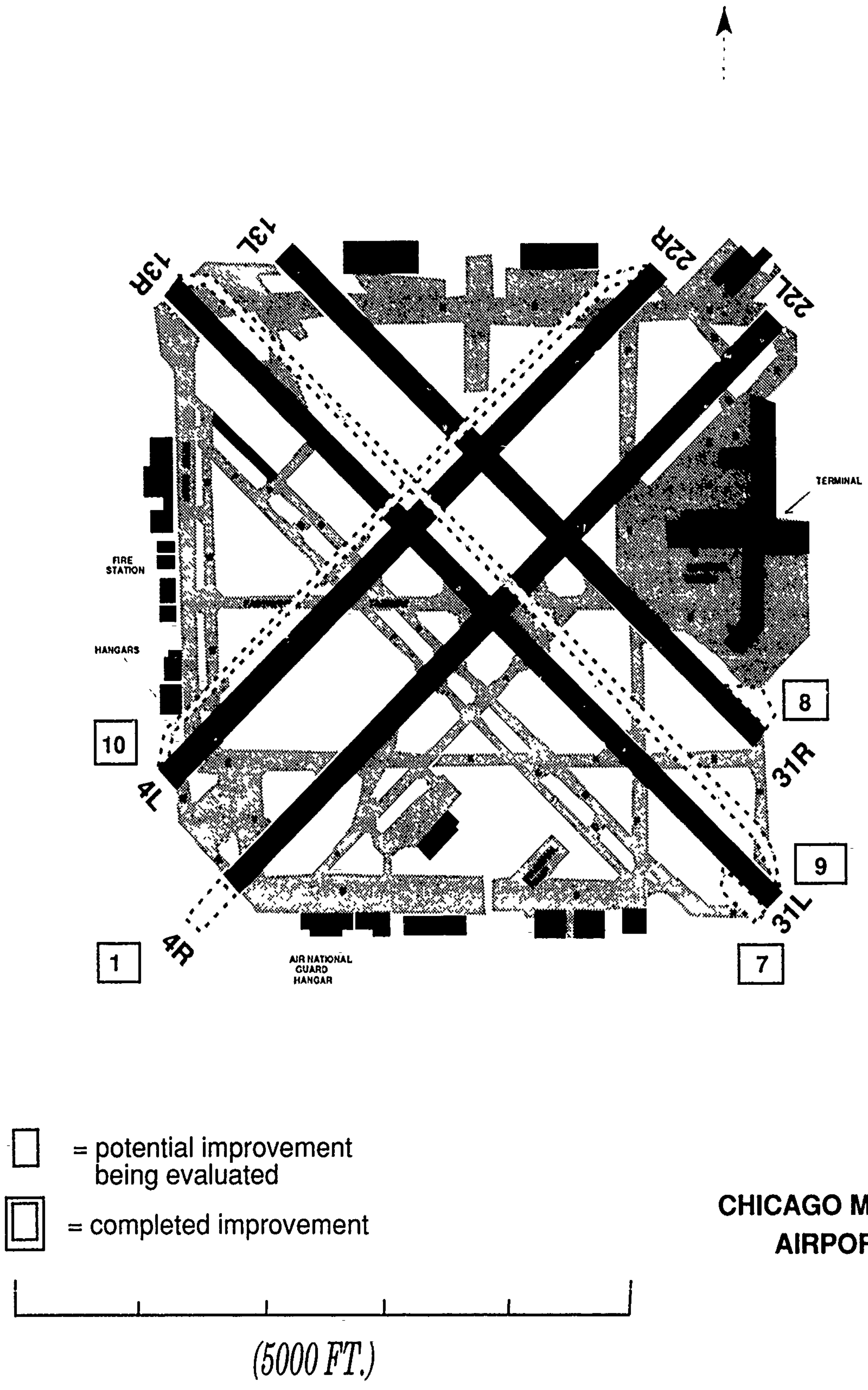
25A. Impact of Noise Restrictions during School Hours, Affects arrivals to 18R — 7:25AM to 2:15PM on school days. Non-Stage III jets cannot arrive on 18R. They arrive on 23.

25B. Impact of Noise Restrictions during Sunday Church Services, 9:30AM until NOON on Sundays. In north flow, all jets land & depart on 5. All other aircraft arrive and depart on 36R. 36L is not used. In south flow, all jets land on 23 and depart on 18L. All others (non-jets) land on 18R and depart on 18R.

26. Identify Departure Restrictions

User Improvements

27. Increase Use of Stage III Aircraft to Reduce Noise. It will reduce the impact of the noise restrictions during school hours. Stage III jets can arrive on 18R during school hours. See Imp 25A.
28. Redistribute Traffic More Uniformly Within the Hour
29. Enhance Reliever Airports



CHICAGO MIDWAY AIRPORT

12/22/89

Chicago Midway Airport
Airport Capacity Design Team Project Summary

Potential Improvements Being Evaluated

Airfield Improvements

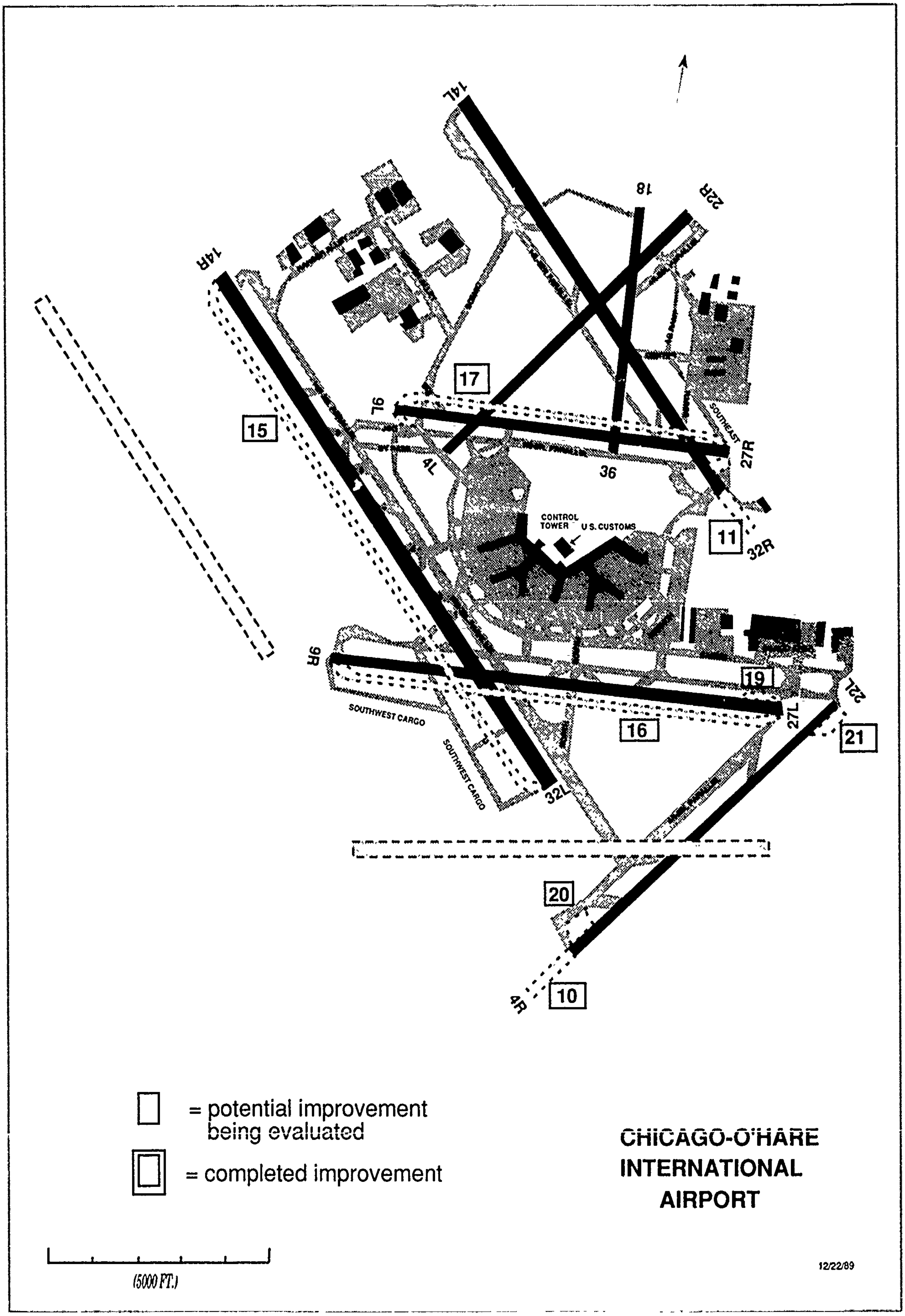
1. Extend Runway 22L by 500 ft.
2. Reduce Arrival Minimums 13R
3. Reduce Arrival Minimums 31L
4. Reduce Arrival Minimums 4R
5. Replace 13L/31R with 14/32
6. Triple Parallel 13/31s
7. Runway 31L Hold Pad
8. Runway 22L Hold Pad
9. 31L/13R Parallel Taxiway (East)
10. 4L/22R Parallel Taxiway (West)
11. Independent 9/27 Runways

Facilities and Equipment Improvements

12a. MLS Runway 22L
12b. MLS Runways 31R, 4L, 13R
13. Offset Approach Runway 13R
14. Precision Approach Path Indicator Runways 4L & 31R
15. New Air Traffic Control Tower
16. Gate Area Expansion

Operational Improvements

17. Meig's IFR Approach
18. Independent Prop and Jet Routes
19. Review Runway Configuration
20. Feeder/Final Approach Control
21. Additional Departure Sector
22. Additional/Relocated Arrival Routes
23. Additional/Relocated Departure Routes


14L
18
22R
14R
17
9L
15
4L
36
27R
CONTROL TOWER
U.S. CUSTOMS
11
32R
9R
19
22L
SOUTHWEST CARGO
SOUTHWEST CARGO
16
27L
21
32L
20
4R
10
= potential improvement being evaluated
= completed improvement
CHICAGO-O'HARE INTERNATIONAL AIRPORT
(5000 FT.)
12/22/89

Chicago O'Hare International Airport
Airport Capacity Design Team Project Summary

Potential Improvement Being Evaluated

Airfield Improvements

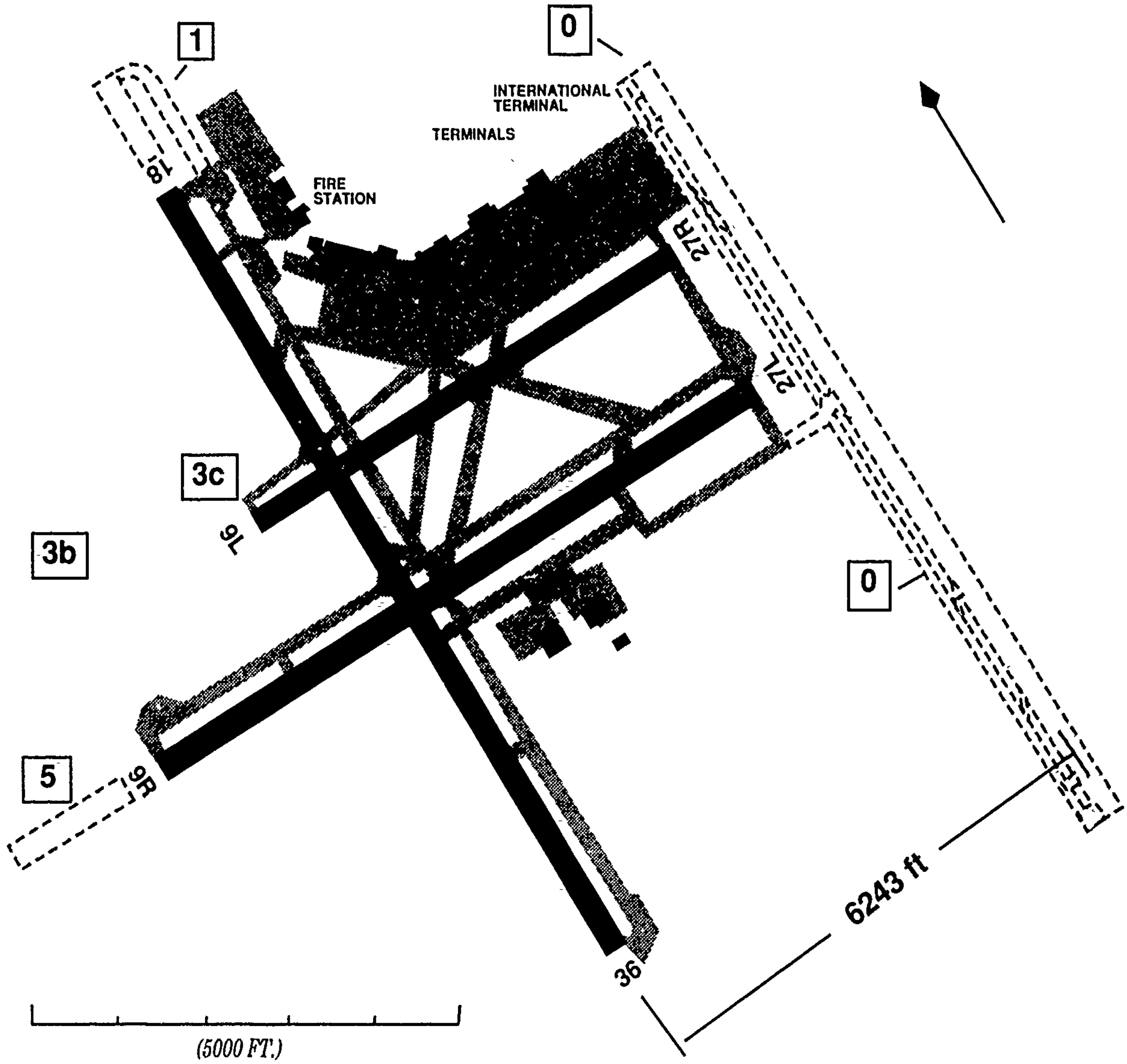
1. New Commuter Runway 14/32
2. New Commuter Runway 9/27
3. New Air Carrier Runway 14/32
4. New Air Carrier Runway 9/27
5. Relocate Runway 9L/27R
6. Relocate/Extend Runway 9L/27R
7. Relocate Runways 9L/27R & 4L/22R
8. Relocate/Extend Runways 9L/27R & 4L/22R
9. Relocate All North Airfield Runways
10. Extend 22L by 1000'
11. Extend 14L by 1000'
12. Runway 9R High Speed
13. Runway 22L Threshold Exit Fillet
14. Runway 27R High Speed
15. Parallel Taxiway 14R/32L (West)
16. Parallel Taxiway 9R/27L (South)
17. Parallel Taxiway 9R/27L (North)
18. Exit Taxiway Centerline Lights
19. Runway 27R Hold Pad
20. Runway 14R Hold Pad
21. Runway 22L Hold Pad
22. Runway 4R High Speed Exit

Facilities and Equipment Improvements

23a. MLS 9R, 32L
23b. CAT II ILS 4R, 27R
24. CAT IIIa ILS 4R, 9R, 14L, 27L, 32L
25. CAT IIIb ILS 14L, 14R
26a. RVR 22L
26b. RVR 22R

Operational Improvements

27. Triple Converging IFR Approaches
28. Independent Wet Runways 14R/9R/27L
29. Independent Wet Runways 14L/9L
30. Remove A/C Type Rest. on Wet Runways
31. Remove 4L Hold Pad Restrictions (Cannot Remove for 747 Aircraft)
32. Feeder Final Approach Control (Sched 9/90)
33. Relocate/Additional Departure Routes
34. Relocate/Additional Arrival Routes (Sched 7/90)



COVINGTON/GREATER CINCINNATI
INTERNATIONAL AIRPORT

Covington/Greater Cincinnati International Airpoort
Airport Capacity Design Team Project Summary

Potential Improvements Being Evaluated

Airfield Improvements

0. New independent Runway 18L/36R. (Included in Baseline)
1. Extend existing Runway 18/36 1500' to the north with single taxiway and staging area.
2. Dual Taxiway S full length.
3a. Move Runway 9L/27R and associated taxiways south 800' north of 27L and extend 1500' to accommodate air carriers.
3b. Extend Runway 27R west to new length of 5300' and use as a departure only runway.
3c. Eliminate Runway 9L/27R.
4. Effect of Delta terminal expansion on Runways 27R & 18L (effect of pushbacks on active taxiways) including penalty box and east/west taxiway parallel to Runway 9R/27L north of Runway 27L.
5. Extend 27L west 2000' to a length of 10,000' with improved exits and associated taxiways.
6. Third North/South parallel commuter Runway 18/36 1000' west of Runway 18R.
7. Third North/South parallel Runway 18/36 full length 2500' from Runway 18R.
8. Improved exits for runways.
9. Expanded staging locations on all runway ends.
10. Relocate tower.
11. South crossfield taxiway between N/S parallel runways.
12. Fourth dual parallel N/S 10,000' runway with 1000' separation from Runway 18L.
13. Perimeter access roads around airport.

Facilities and Equipment Improvements

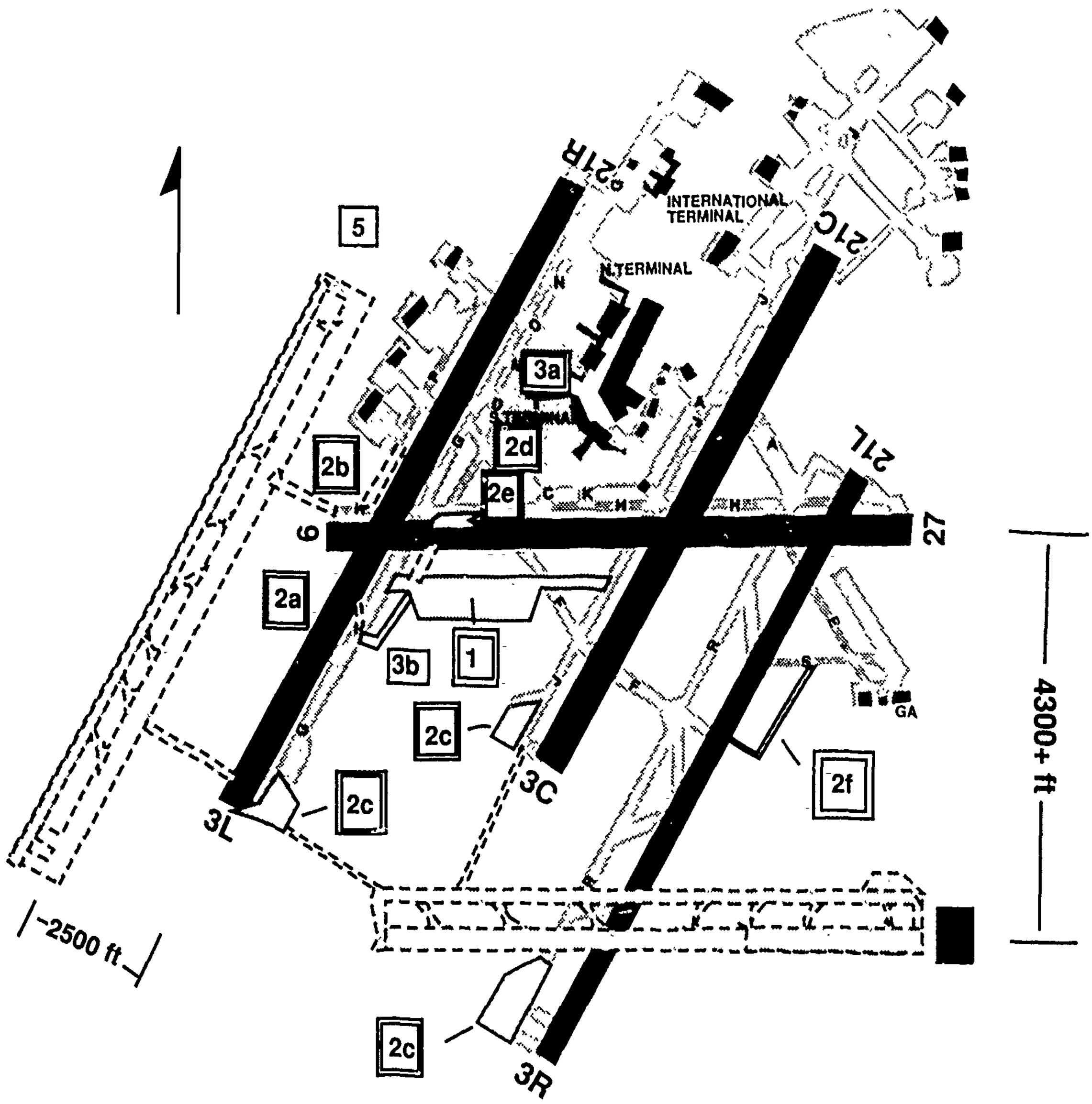
14. RVR's for all runways.
15. Relocate VOR to airfield.
16. ASDE III.
17. Install VOR to eliminate overflights.
18. TRACON expansion.
19. Benefit of additional BRITE displays.

Operational Improvements

20. Effect of TCA.
21. Revise airspace to eliminate overflights.
22. Effect of revised departure procedures.
23. More use of Stage III aircraft.
24. Extra snow removal equipment.
25. Benefit of MLS.
26a. Effect of expanded GA activity.
26b. GA reduction - enhance reliever airports.
27. Impact of Runway closures/outages for equipment or routine maintenance.

User Improvements

28. Uniformly distribute scheduled operations within the hour.
29. Pilot education for reduced runway occupancy time.



= recommended improvement

= completed improvement

(5000 FT.)

DETROIT METROPOLITAN WAYNE COUNTY AIRPORT

12/22/89

Detroit Metropolitan Wayne County Airport
Airport Capacity Design Team Project Summary

Recommended Improvements

Airfield Improvements

1. Holding Apron and Taxiway South
2. Runway and Taxiway Improvement Package
   a. Highspeed Exit Taxiway - Runway 21R to Taxiway Y
   b. Extend Taxiway Z to Taxiway V
   c. Construct and Expand Holding Aprons at Runways 3C, 3L, and 3R
   d. Extend Inner Taxiway Parallel to Taxiway H
   e. Construct Exit Taxiway - Runway 9/27 to Taxiway H
   f. Construct Taxiway S to East GA Area

3a. Terminal Expansion
3b. Mid-Field Terminal
4. Construct Independent Crosswind Runway - 9R/27L
5. Construct Independent 4th N/S Runway

Facilities and Equipment Improvements

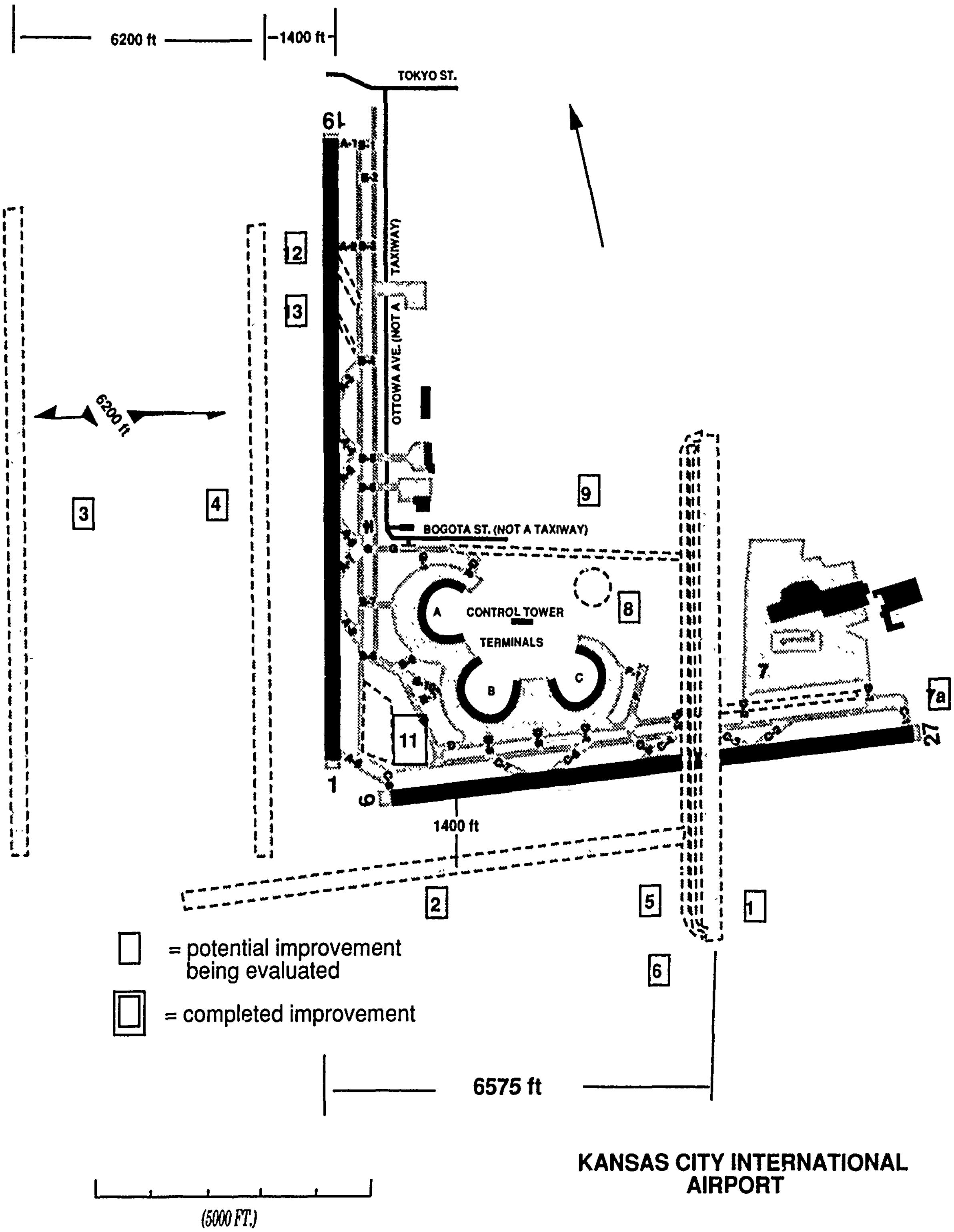
7a. ILS MLS and Approach Lights on Existing Runway 3C
7b. RVR for Existing Runway 3C
8. ASDE
9. Terminal Doppler Weather Radar
11. RVR and Centerline Lights on Runway 27
12. Expedite Development and Installation of Wake Vortex Forecasting and Avoidance System
13. Install an Airport VOR

Operational Improvements

14. Independent Converging VFR/IFR Approaches to Runways 27 and 21R, Hold Short of 21R
15. Add Controller Positions Establish STAR Routes, Relocate MOTER Intersection
16. Use Departure Corridors
17. Realign Cleveland Center Sector Airspace
18. Expand Tower En Route Program
19. Reduce Arrival Longitudinal Separation to 2.5NM
    a. Runway Occupancy Time Reduced 10%
    b. Runway Occupancy Time Reduced 20%
    c. Runway Occupancy Time Reduced 30%

User Improvements

20. Relocate General Aviation Traffic Users
21. More Uniform Distribution of Scheduled Operations Within the Hour



KANSAS CITY INTERNATIONAL AIRPORT

Revised 7/06/90

Kansas City International Airport
Airport Capacity Design Team Project Summary

Potential Improvements Being Evaluated

Airfield Improvements

1. New N/S 9500' independent runway (1R/19L)
2. New dependent 10,000' parallel runway 9R/27L to south of 9L/27R
3. New independent 10,000 parallel runway 18R/36L to west of 9L/27R
4. New dependent 10,000 parallel runway 18L/36R to west of 9L/27R
5. Single parallel taxiway (including holding aprons) full length 1R/19L
6. Dual parallel taxiway to Runway 1R/19L (full length)
7. Extend Taxiway D east to D2
   a. Extend Taxiway D to D1
8. Add fourth terminal
9. Extension of Taxiway G to new runway 1R/19L
10. Extension of Taxiways B & D to Taxiway H (not pictured)
11. Build holding aprons west of Terminal B
12. High speed exit at A2
13. High speed exit at A3 for Runway 19
    a. Extend B5 to Runway for exit for GA Runway 19 and change for A2 exit additional high speed west for C5 of Runway 27

Facilities and Equipment Improvements

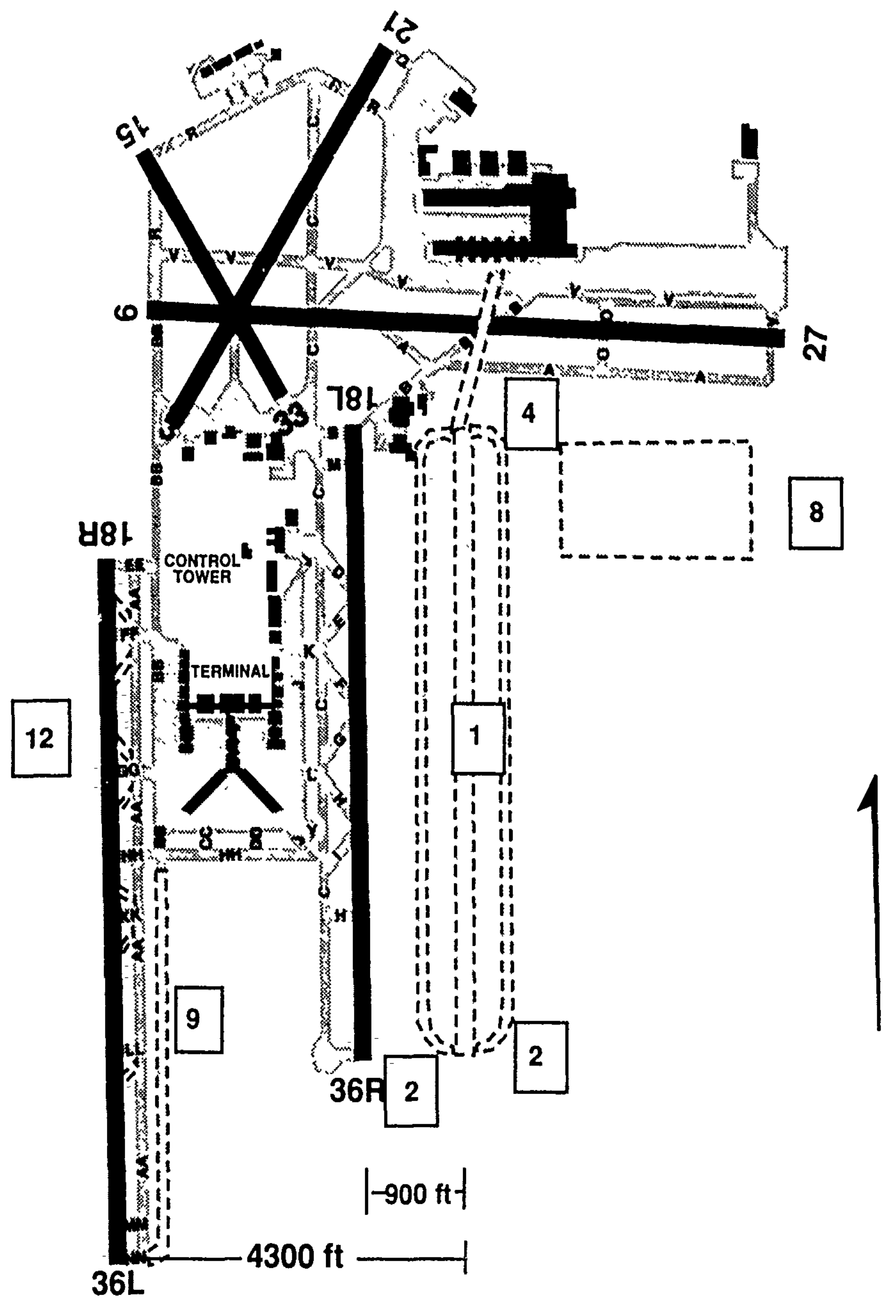
14. CAT III ILS on 1R
15. CAT I ILS on 19L
16. ILS/MLS on existing Runway 27
17. DME for Runway 1L/19R and 1R/19L
18. RVR for new Runway 1R/19L
19. Upgrade Runway 1L ILS to CAT III
20. Benefit of ASDE
21. Relocate VOR to airport and KINSEY outer marker to 4 miles from downtown Runway 19 and increase glide angle to Runway 27

Operational Improvements

22. Reduce arrival longitudinal separations to 2.5 ml for like class aircraft
23. Simultaneous IFR converging approaches
24. Impact of terminal service road
25. Impact of perimeter service road
26. Effect of noise restrictions
27. Effect of ARSA type separations within the TCA

User Improvements

28. Uniformly distribute traffic within the hour
29. Make AIM (Airman's Information Manual) a regulatory document
30. Reduce ROT's through pilot and controller education (stop use of reverse high speeds)



MEMPHIS INTERNATIONAL AIRPORT

☐ = recommended improvement

▣ = completed improvement

(5000 FT.)

12/22/89

Memphis International Airport
Airport Capacity Design Team Project Summary

Recommended Improvements

Airfield Improvements

1. Construct Runway 18E/36E, Dual Departures
2. Construct Runway 18E/36E, Triple Departures in VFR-1
3. Construct Runway 18E/36E, Triple Departures in all Weather Conditions (Waiver Required)
4. Extend Inner Taxiway S North to Taxiway V—Use as Base for Future Construction (Not Pictured)
5. Extend Outer Taxiway P North to V
6. Extend Runway 18L/36R South
7. Extend Taxiway A From B to BB For Existing Runways and Future Runways
8. Large Freight Ramp, E of 18E, S of 27—Base for all Runs
9. Extend N/S Taxiway BB to Approach End of Runway 36L
10. New Crossover Taxiway South of HH—Base for all Runs (Not Pictured)
11. Terminal Expansion (Not Pictured)
12. Angled Exits on 18R/36L (Reduce Occupancy Times by 10%)

Facilities and Equipment Improvements

13. CAT II/III ILS on Runway 36R
14. CAT II/III on ILS Runway 36E
15. CAT II/III ILS on Runways 18R, 18L and 18E
16. Install ASDE (Airport Surface Detection Equipment)
17. Reroute High Altitude Traffic Away from MEM VORTAC

Operational Improvements

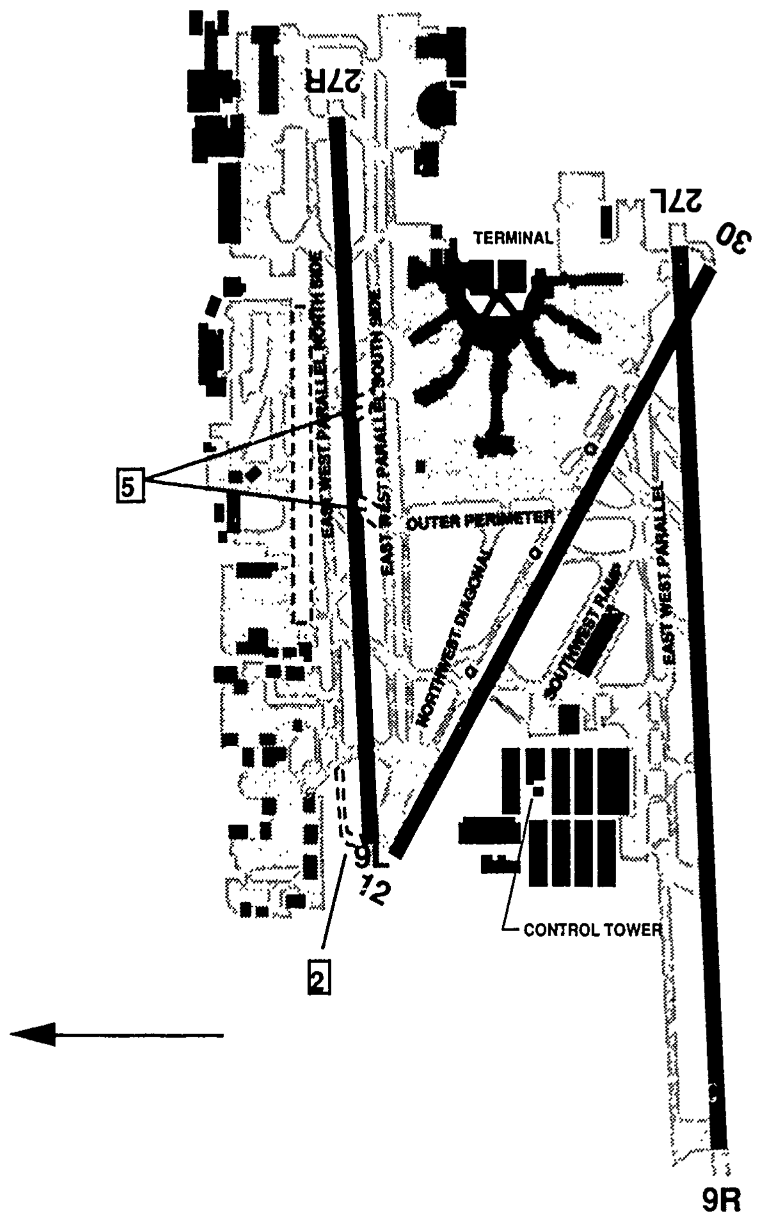
18. Reduce Longitudinal Spacing to 2.5 NM Between Similar Class, Non-Heavy Arrivals For Existing Runways and Future Runways
19. Reduce Lateral Spacing (Simultaneous ILS Approaches to Existing Parallels)
20. Small Aircraft Hold Short of Runways 3/21 & 15/33 When Landing Runway 27 (Regardless of Wind)
21. 1.5 Mile Staggered ILS Approach to Existing Parallels
22. Relief from Airspace Criteria

User Improvements

23. Reduce Small-Slow Aircraft by 10%
    Reduce Small-Slow Aircraft by 25%
24. Uniformly Distribute Traffic Within the Hour for Existing Runways and Future Runways
25. Increase GA Forecast by 20%
26. Relocate Air Guard to Naval Air Station (off of airport) (Not Pictured)

Special Runway Usage

27. Runway 18E/36E with Triple VFR Departures



□ = potential improvement being evaluated

▣ = completed improvement

(5000 FT.)

MIAMI INTERNATIONAL AIRPORT

12/22/89

Miami International Airport
Airport Capacity Design Team Project Summary

Recommended Improvements

Airfield Improvements

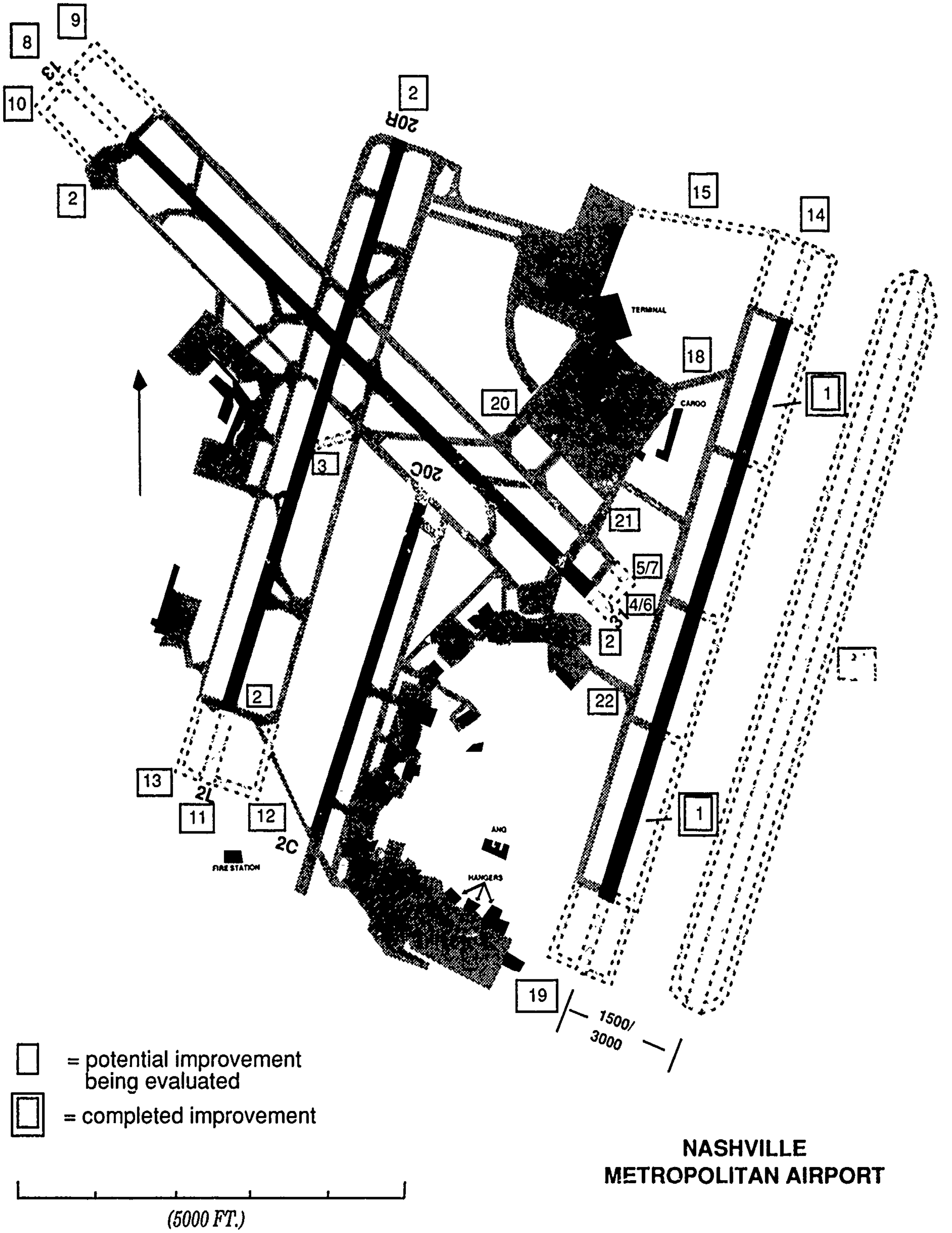
1. Duai Taxiway Around Concourse H (Remove 2 End Gates) (Not Pictured)
2. Extend Taxiway L to End Runway 9L
3. Construct New Partial Dual Taxiway K
4. Develop Improved Exits for 9L/27R Northside (Not Pictured)
   a. Strengthen/Reconstruct 9L/27R
5. Improve Exits M4 and M5 on 9L/27R

Facilities and Equipment Improvements

6. CAT II on Runway 9L
7. CAT II on Runway 9R
8. Install Touchdown and Midpoint RVR on Runway 9R
9. VOR/DME (on airport)
10. Glideslope, MALSR and Middle Marker on Runway 30
11. ASDE
12. Benefits of MLS
13. Install Midpoint and Rollout RVR on 9L

Operational Improvements

14. Independent Converging IFR Approaches to Runways 12 and 9R
15. Independent Converging IFR Approaches to Runways 27R and 30
16. 2.5 Mile In-Trail Longitudinal Approach Separation (IFR)



NASHVILLE METROPOLITAN AIRPORT

Nashville Metropolitan Airport
Airport Capacity Design Team Project Summary

Potential Improvements Being Evaluated

Airfield Improvements

1. New 8000 Ft. Air Carrier Runway, 2R/20L, with Associated Taxiways
2. Run-up Pads for All Runway Ends
3. Mid-field Diagonal Connector Off Rwy 2L to Twy C-7
4. Extend Rwy 13/31 500 Ft. to the Southeast for Departures
5. Extend Taxiway L Connector 500 Ft. to the Southeast
6. Extend Rwy 13/31 700 Ft. to the Southeast for Departures
7. Extend Taxiway L Connector 700 Ft. to the Southeast
8. Extend Rwy 13/31 1000 Ft. to the Northwest
9. Extend Taxiway L 1000 Ft. to the Northwest
10. Extend Taxiway C 1000 Ft. to the Northwest
11. Extend Rwy 2L/20R 1300 Ft. to the South
12. Extend Taxiway B 1300 Ft. to the South
13. Extend Taxiway A 1300 Ft. to the South
14. Extend New Rwy 2R/20L 1000 Ft. to the North, with Associated Taxiways
15. North-side Crossover Taxiway (one-way) to Connect North Side of Ramp to the New Rwy 20L (This Requires the 1000 Ft. Rwy 2R/20L Extn.)
18. Connecting Taxiway from Concourse C to the New Rwy 2R/20L
19. Extend New Rwy 2R/20L 1000 Ft. to the South, with Associated Taxiways
20. Dual Lanes at Taxiway T-4
21. Dual Lanes at Taxiway T-6
22. Extend Taxiway C to New Parallel Runway (Taxiway H)
23. Connecting Taxiway From G.A. Area to Rwy 31 Departure End
24. Apron Edge Dual Lanes
25. Diagonal Dual Lanes
28. Round Off Fillet at Taxiway C and Rwy 2L
29. Effect of Terminal Expansion, e.g., Concourse A
31. Benefit of Penalty Box
32. Expansion of Service Roads
33. High-speed Exit from 2L/20R (near R-1)
34. Third Parallel Runway (1500-3000 Ft. to the Right of New 2R/20L)

Facilities and Equipment Improvements

35. ILS and MALSR on Rwy 13
36. CAT I ILS for New Rwy 20L
37. CAT II/III ILS for New Rwy 2R and Existing 2L
38. CAT III ILS for New Rwy 20L and Existing Rwy 20R
39. MALSR Lights to Rwy 31 and Rwy 20
40. Lead-in Lights on Rwy 2C for Side-step Approach from Rwy 2L
41. Upgrade Reliever Airports by Installation of Precision Approaches
42. Low-level Wind Shear Advisory System (LWAS)
43. Airport Surface Detection Equipment (ASDE)

continued on next page

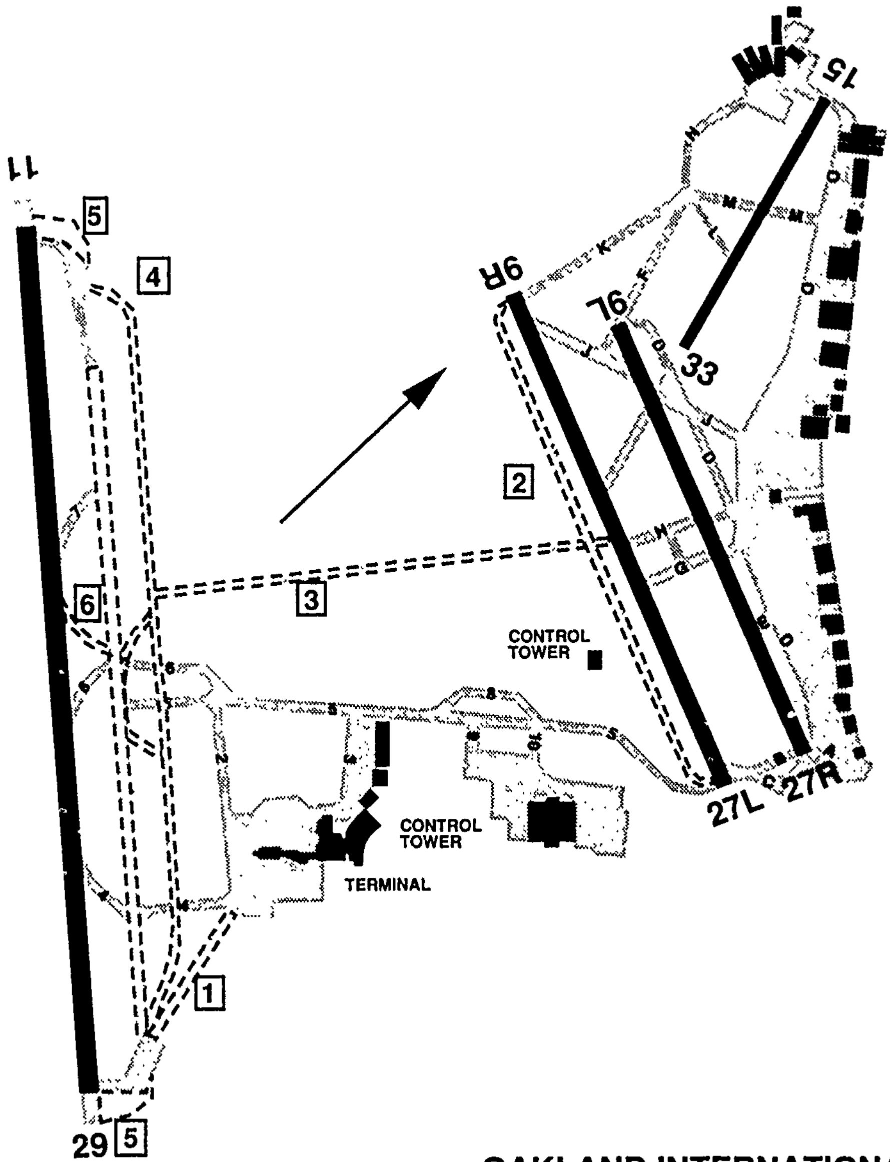
Nashville Metropolitan Airport
Airport Capacity Design Team Project Summary (continued)

Operational Improvements

44. Side-step Approach from Rwy 2L to Rwy 2C for Light Aircraft
45. Reduce Arrival Separations Between Like-Class Aircraft to 2.5 nmi on All Runways Except New 20L
46. Converging Approaches on Rwy 13 and the New Rwy 20L and Departures on Rwy 20R
47. Benefit of Wake Vortex Advisory System (WVAS) and Vortex Avoidance System (VAS)
48. Air vs. Ground Crossovers
49. Effect of Noise Abatement (Impact of Quieter Jets)
50. Heavy Departures on the New Rwy 2R and Rwy 2L vs. Heavy Departures on Rwy 13/31
51. Revise Departure Airspace
52. Effect of Exanding Terminal Airspace
53. Relocate LNG Fix Northwest to the 335° Radial
54. Effect of Instituting TCA at BNA
55. Revise Low Altitude Air Routes

User Improvements

56. Reduce Runway Occupancy Times (Through Pilot Education)
57. Encourage G.A. Usage of Alternative Airports by Upgrading Facilities at Smyrna and Tune (Accomplished by Reducing G.A. from 35% to 25% to 10% in the Simulation Schedule)
58. G.A. Reservation System During Peak IFR Periods
59. Relocate Air National Guard to Another Airport
60. Increase Percentage of Heavy Aircraft in the Fleet Mix (10% Increase in Heavy Operations)
61. Uniformly Distribute Scheduled Operations Within the Hour
62. Strengthen Runway 2L/20R for Military Use
63. New Exit From Runway 20R at 5000 ft. from Commuter Type Aircraft
64. Construct Deicing Facility



OAKLAND INTERNATIONAL AIRPORT

☐ = recommended improvement

☐ = completed improvement

(5000 FT.)

12/22/89

Oakland International Airport
Airport Capacity Design Team Project Summary

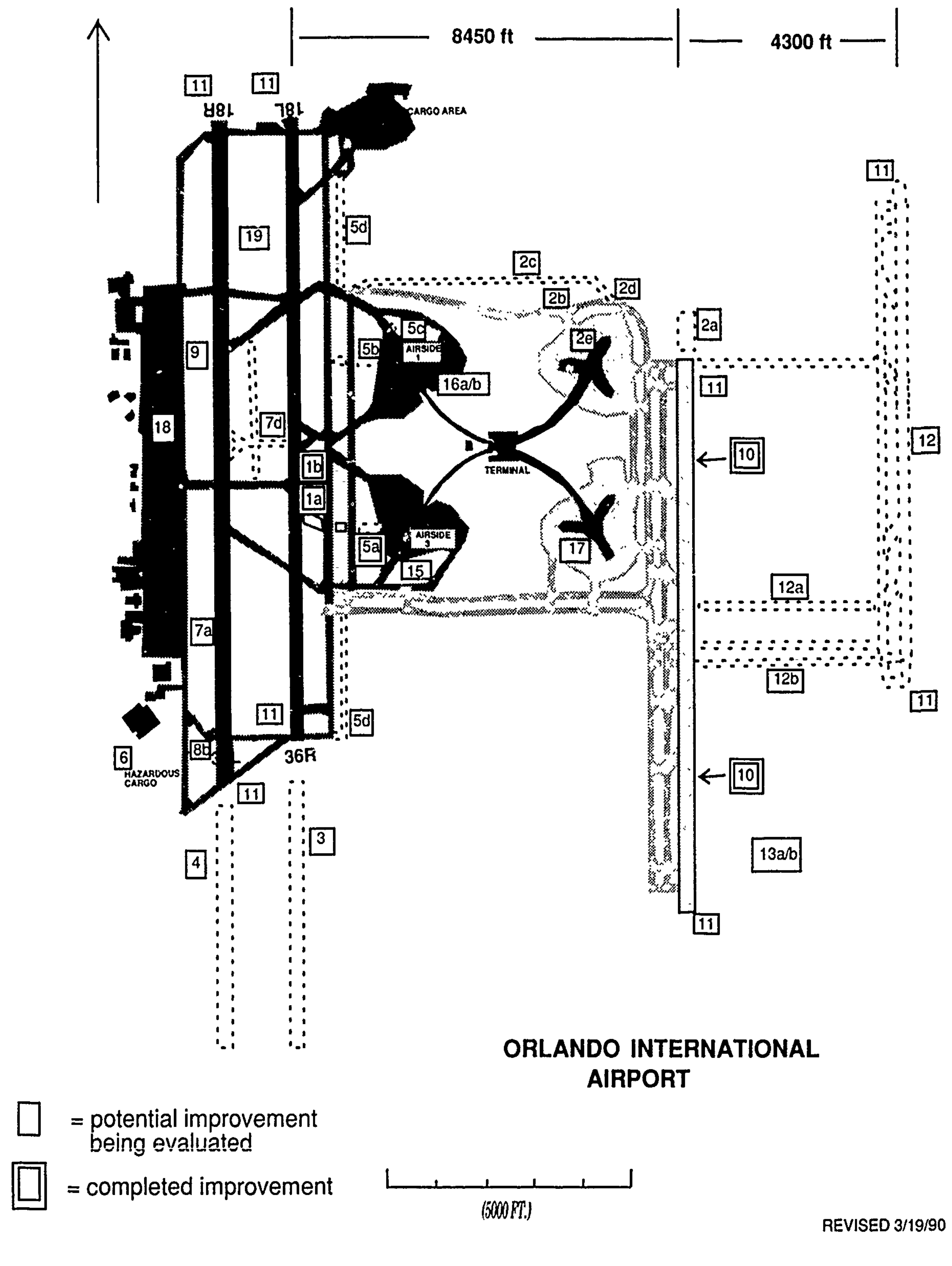
Recommended Improvements

Airfield Improvements

1. Construct Taxiway From SE Corner of Terminal to Runway 29 Approach Threshold
2. Build Taxiway Parallel to Runway 27L
3. Add Taxiway Between North and South Complexes
4. Convert Taxiway 1 to Air Carrier Runway 29 and Add Parallel Taxiway
5. Enlarge Staging Pads at Entrances to Runway 11/29
6. Construct Additional Angled Exit Off Runway 11
7. Build Penalty Box on South Side of Approach End of Runway 29

Facilities and Equipment Improvements

8. Install MLS on Runways 29 and 27
9. Install a Non-Directional Beacon Approach to Runway 29


8450 ft
4300 ft
11
18R
18L
CARGO AREA
19
5d
2c
2b
2d
2a
5c
5b
AIRSIDE 1
9
16a/b
2e
7d
18
1b
1a
TERMINAL
10
12
5a
AIRSIDE 3
15
17
12a
7a
12b
11
36R
8b
6
HAZARDOUS CARGO
3
4
13a/b
ORLANDO INTERNATIONAL AIRPORT
= potential improvement being evaluated
= completed improvement
(5000 FT.)
REVISED 3/19/90

Orlando International Airport
Airport Capacity Design Team Project Summary

Potential Improvements Being Evaluated

Airfield Improvements

1a. Construct Angled Taxiway
1b. Reconstruct and Improve Exit Taxiways 8A and 8B
2a. Extend Runway 17R 1000' to the North
2b. North Crossfield Taxiway
2c. Parallel North Crossfield Taxiway
2d. Outer Taxiway on Airside 2
2e. Fourth Airside (Airside 2)
3. Extend Runway 18L 8000' to South
4. Extend Runway 18R 8000' to South
5a. Connector Taxiway to Airside 3
5b. Connector Taxiway Between Taxiway B and Airside 1
5c. Connector Taxiway Between Taxiway 7 and Airside 1
5d. Extend Taxiway C to 18L
Extend Taxiway C to 36R
6. Ingress/Egress Taxiway to Military Area Near Tradeport South
7a. Exit Taxiway to GA/Charter Facilities
7d. Construct Mid-Field Taxiway System Between Runways 18L/R - 36L/R
8a. New Bypass Taxiway to Runway 36R and 36L
8b. New Bypass Taxiway from Taxiway A to Threshold of 36L
9. Angled Taxiway to West on 36L/18R
10. Third Runway With Crossfield Taxiway
11. Staging Areas at All Runway Ends
12. Fourth Runway
    a. Connector Taxiway Inline With Crossfield
    b. Connector Taxiway To End of Runway
13. Fifth Runway:
    a. Departures Only (to South)
    b. Departures to and Arrivals From South
15. Connector Taxiway Between Taxiway 9 and Airside 3
16a. Expand Apron/Taxiways Associated with Airside 1
16b. Reconstruct Airside 1 with 24 Gates
17. Construct Apron/Taxiways Associated with Airside 4
18. Expand Cargo Apron Areas
19. Relocate Bypass Taxiway 6 to the North

Facilities and Equipment Improvements

20. Install VOR at MCO
21. Install CAT III ILS on All 8 Runways
22. Install MLS
23. Install ASDE

continued on next page

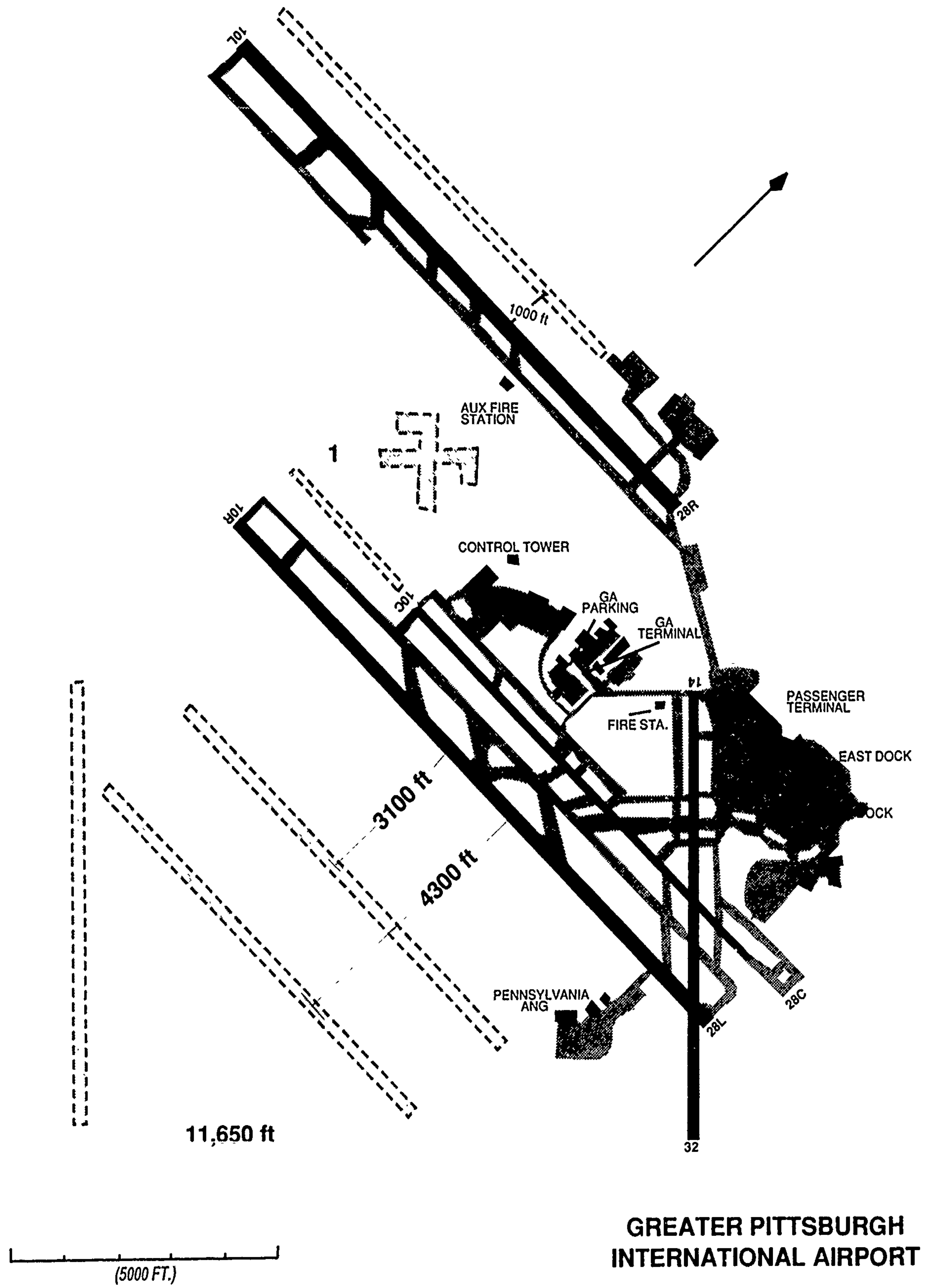
Orlando International Airport
Airport Capacity Design Team Project Summary (continued)

Operational Improvements

24. Implement Ramp Control
25. Construct Second ATC Tower
26. Reduce Intrail Separations From 3 nm to 2.5 nm
27. Implement Wake Vortex Advisory System for Close Intrail Spacig
28. Increase Percent of Stage 3 Aircraft (30%, 60%, and 100%) Use of North Departures to +WORMS+ to Meet Current Noise Abatement Restrictions
29. Implement Triple Parallel Approaches
30. Implement Quadruple Departures
31. Restructure Terminal Airspace
32. Restructure Airways
33. Implement Staggered Approaches on 18L/R and 36L/R
34. Use Ground Crossovers vs. Air Crossovers
35. Segregate Commuter, GA, and Helicopter Operations

User Improvements

36. Uniformly Distribute Scheduled Operations Within the Hour
37. Encourage GA Use of Alternative Airports by Providing New East and West Reliever Airports



GREATER PITTSBURGH INTERNATIONAL AIRPORT

Greater Pittsburgh International Airport
Airport Capacity Design Team Project Summary

Airfield Improvements

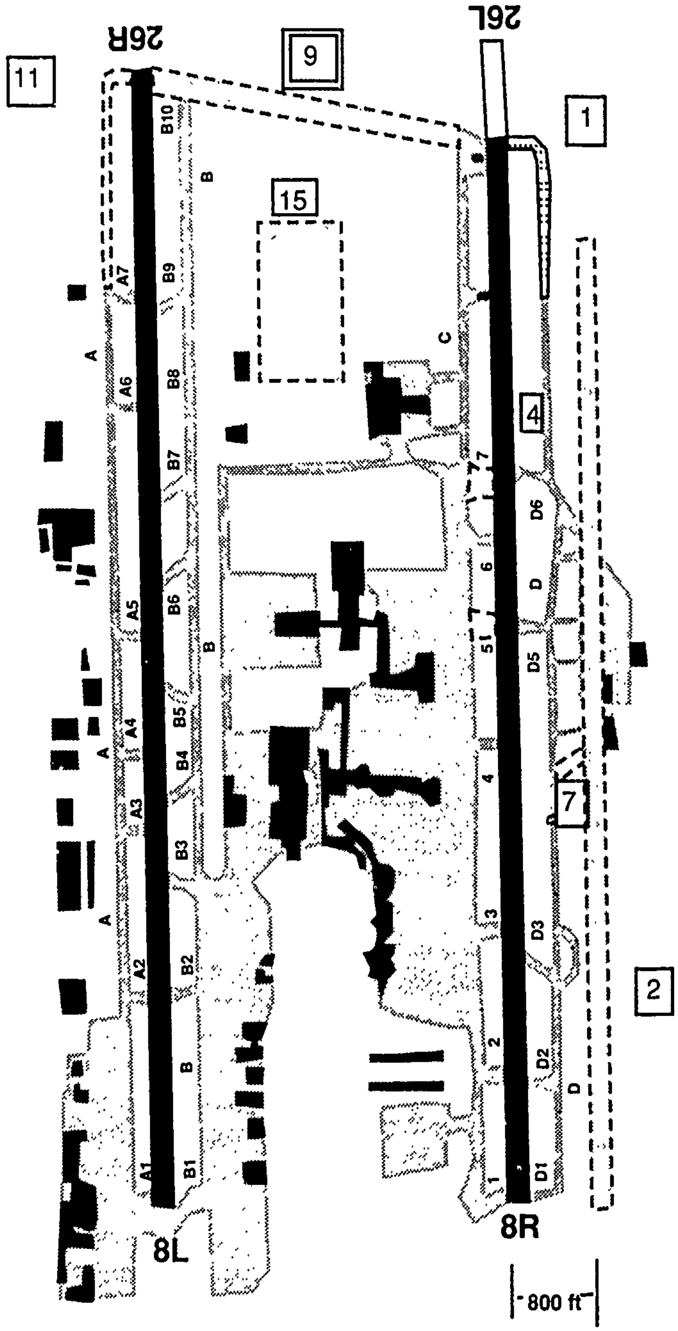
1. Extend Runway 10C
2. New Runways
   a. 10,000 ft. 14R/32L, 11,650 ft. SW of 14/32
   b. 8,000 ft. 9/27, 4,300 ft. South of 10R/28L
   c. 5,000 ft. 9/27, 4,300 ft. South of 10R/28L
   d. 10,000 ft. 9/27, 3,100 ft. South of 10R/28L
   e. 5,000 ft. 14R/32L at (?) (not pictured)
   f. 8,000 ft. 10N/28N, 1,000 ft. North of 10L/28L
3. New Taxiways
   a. Twy F (N-1 to W) (Outer)
   b. Rwy 10R High Speed to P
   c. Twy A
   d. Rwy 28R @ N-7
   e. Rwy 32 Fillet @ V
   f. Twy D (Inner)
4. Expand 28R Hold Pad
5. Terminal Improvements
   a. 74 Gate Midfield Development
   b. 25 Gate Commuter Terminal
   c. Phase III AC Terminal
   d. Phase II RA Terminal

Operational Improvements

6. Simultaneous Hold Short Wet Rwys 10L & 10R (Operational Evaluation)
7. SCIA 28R & 32
8. 2.5 nm Intrail
9. VOR Rwy 14
10. TMC

Facilities and Equipment Improvements

11. 10C/10R Runway Visual Range (RVR)
12. ASDE-3
13. Airport Surveillance Radar-9
14. MLS 28L, 32, 10L
15. PAPI 10R, 28C
16. PAPI 28L, 10C, 14, 32, 28R
17. CAT II 10R
18. CAT II 28R
19. Low Level Windshear Alert System
20. Reil/Rail Rwy 14
21. Visual Approach Slope Indicator-6 Rwy 10C
22. CAT III 10L



☐ = recommended improvement

⧈ = completed improvement

(5000 FT.)

PHOENIX-SKY HARBOR INTERNATIONAL AIRPORT

REVISED 3/19/90

Phoenix - Sky Harbor International Airport
Airport Capacity Design Team Project Summary

Recommended Improvements

Airfield Improvements

1. Extend Taxiway Delta (D) to End of Runway 26L
2. Construct New Runway 800' South of RWY 8R/26L
3. Construct Run Up Pads at Two Runway Ends (Not Pictured)
4. Widen Fillets at Taxiway C5 and C7 Off Runway 8R/26L
5. Construct Holding Area (Penalty Box) SE of Terminal 3 (Not Pictured)
6. Construct Angled Exit Off of Runway 8R/26L Between Taxiways C3 and C4 TWY C (Not Pictured)
7. Construct Angled Exit Off of Runway 8S/26S Between Taxiways D3 and D5 to TWY D
8. Construct Crossover Taxiway Y Adjacent to Taxiway X
9. Construct Crossover Taxiway W at RWY Ends 26R and 26L
10. Construct Crossover Taxiway West of Terminal 1 (From Exit B3 to Exit C3) (Not Pictured)
11. Extend Taxiway A to RWY End 26R
12. Extend Taxiway BB to Crossover Taxiway W (Not Pictured)
13. Construct Taxiway CC From Exit C8 (East of DYNAIR) to Cross-over Taxiway W (Not Pictured)
14. Complete Northside Taxilane (Parallel to TWY C) From RWY End 8R to Cross Over Taxiway X (Not Pictured)
15. Construct Terminal 4 (77 Gates) and Remove Terminal 1
16. Relocate ANG South of RWY 8R/26L (Not Pictured)

Facilities and Equipment

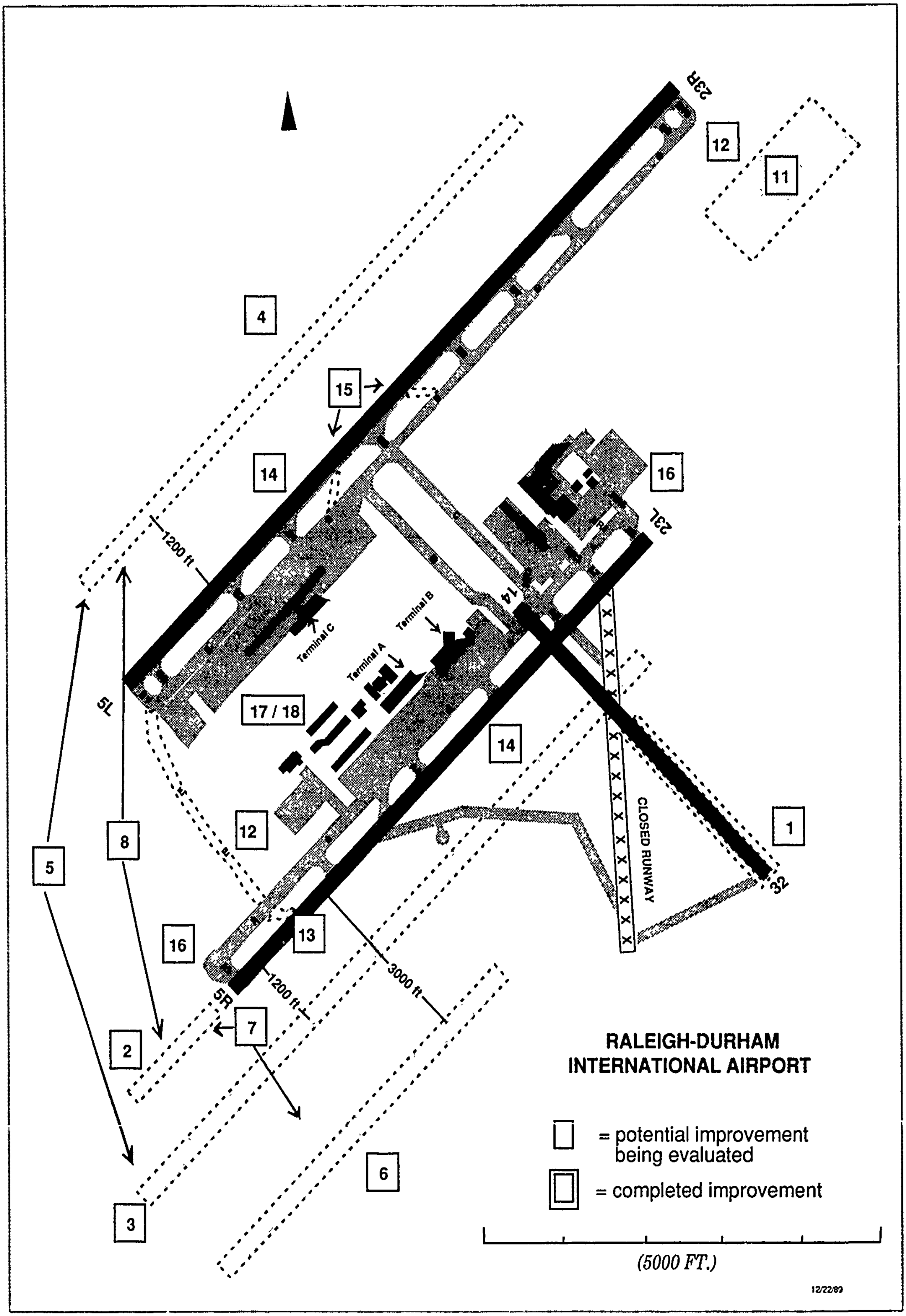
19. Install TVOR/VORTAC in Northern Valley
20. Install ILS (CAT I) for RWY 26R (Ref. Items 27 & 28)
21. Install ILS (CAT I) MLS for RWY 8L (Ref. Items 27 & 28)
22. Determine Benefits of MLS
23. Install VORTAC near Airport

Operational Improvements

25. Reduce Intrail Longitudinal Separations to 2.5 Miles
26. Reduce Runway Occupancy Times (ROT) on RWYs 8R/26L and 8L/26R
27. IFR Dependent Close Parallel Approaches
28. IFR Independent Parallel Approaches
29. Remove Intrail Departure Restrictions to Allow Simultaneous Departures
30. Segregate Fast and Slow Aircraft for Arrivals and Departures
31. Reduce Noise Restrictions: Utilize Special Turboprop Corridors
32. Reduce DEP/ARR Separations for Intersection Departures (Arrivals (Arrivals Hold Short of Take Off Point)

User Improvements

33. Uniformly Distribute Traffic Within the Hour
34. Provide Attractive Alternate Facilities for GA at Other Airports (Retain 90%; 75%; 50% GA)



23R
12
11
4
15
14
16
23L
1200 ft
14
Terminal C
Terminal B
Terminal A
5L
17 / 18
14
CLOSED RUNWAY
1
12
8
5
32
16
13
3000 ft
1200 ft
5R
7
2
RALEIGH-DURHAM
INTERNATIONAL AIRPORT
= potential improvement being evaluated
= completed improvement
6
3
(5000 FT.)
12/22/89

Raleigh - Durham International Airport
Airport Capacity Design Team Project Summary

Potential Improvements Being Evaluated

Airfield Improvements

1. Independent GA Rwy 14/32 (Not Physically Intersecting)
2. Extend Rwy 23L SW to 9000' Length, with Parallel Twys
3. Relocate Rwy 5R/23L 1200' South, at 9000' Length (Use Same Twy)
4. New 8000' Air Carrier Runway, 1200' West of Runway 5L/23R
5. Rwy 5R/23L Relocated 1200' SE at 9000' Length Plus New 8000' Rwy 1200' NW of 5L/23R
6. New 5400' GA Rwy, 3000' east of Runway 5R/23L with Taxiway
7. Rwy 5R/23L at 9000' Length Plus 5400' GA Rwy 2500' SE of Rwy 5R/23L
8. Rwy 5R/23L at 9000' Length Plus 8000' Rwy 1200' NW of 5L/23R
11. New Cargo Area & Twy Connectors with Existing Parallel Twy
12. Parallel Twy to E Feeder Twy & Twy from Cargo Area to 5L/23R
13. High Speed Exit from Rwy 23L to Twy "E" (Not in Baseline, but in All Future Experiments)
14. Full Length Dual Parallel Twys for Existing Runways
15. Angle Exits on 5L/23R Between B4 & B5, and B6 (btwn B5 & B6)
16. Expanded Run-up Pads on Runway 5R/23L
17. Effects of Terminal Expansion
18. Relocate Terminals A & B to West

Facilities and Equipment Improvements

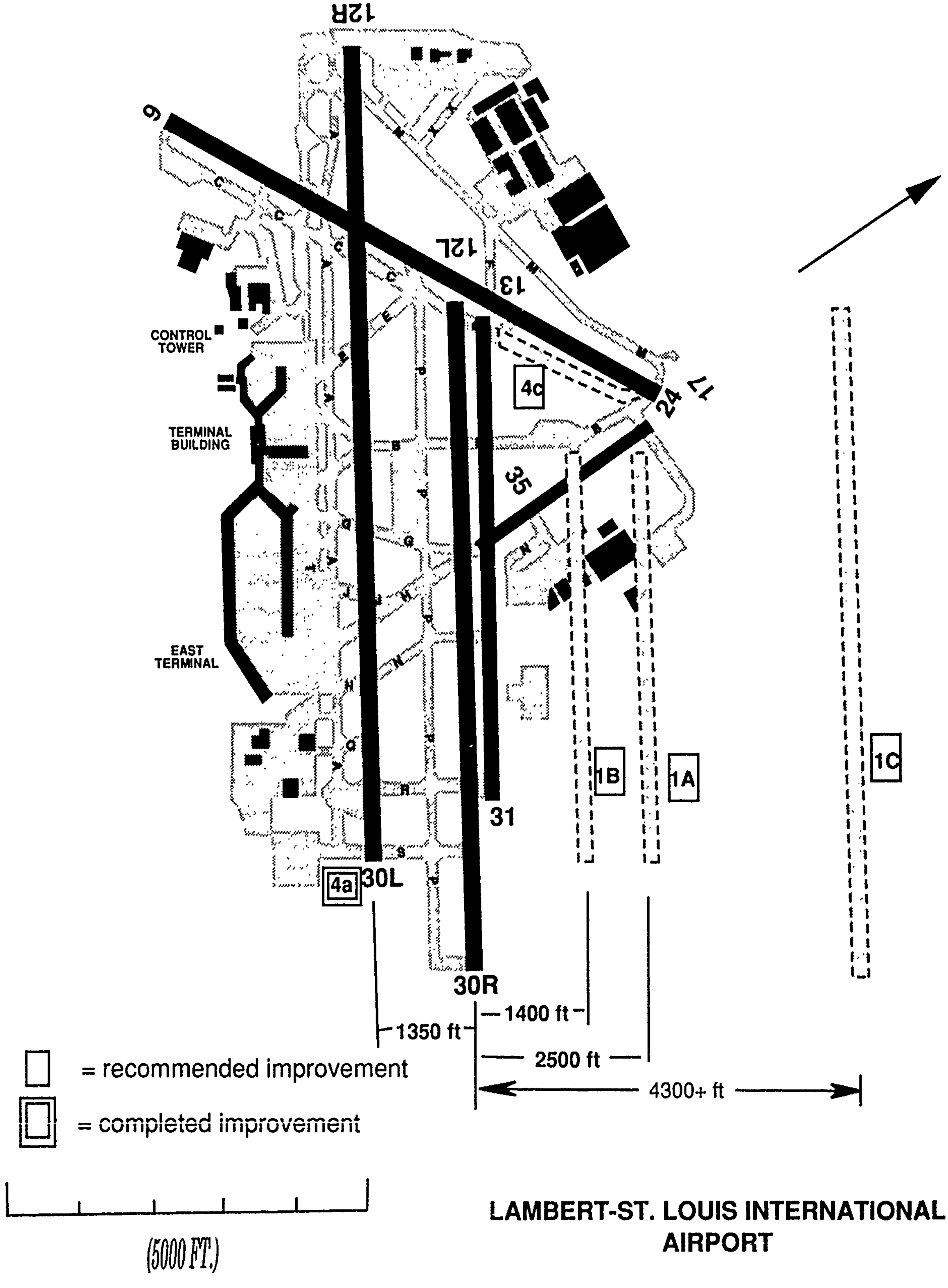
19. Approach Lights to Runway 5L
20. CAT II ILS on Runway 5L & 5R/23L
21. CAT III ILS on Runway 5L/23R & 5R/23L
22. RVR on Runway 5R/23L
23. WVAS (for Heavies)
24. ASDE

Operational Improvements

25. 1.5 NM Staggered Approaches
26. Dependent & Independent Approaches to Existing Runways
27. 2.5 NM Longitudinal Spacing Between Similar Class, Non-Heavy Arr
28. Use of SIDS and STARS
29. Effect of TCA
30. Effect of Noise Abatement Procedures
31. Ground vs. Air Crossovers from Terminals A/B and C
32. Revised Airspace Routes
33. Resectorization
34. Effect of Pushbacks into Taxilanes A & F
35. Segregation of Rotorcraft Air Craft
36. LDA Approach 5W/23W (Staggered Approaches to 23/R & 23W)

User Improvements

37. Uniformly Distribute Traffic Within the Hour (Depeak)
38. Fleet Mix Changes
    a. Introduce Heavies
    b. GA Reduction — GA Reliever Airports
    c. Effect of Increased Cargo Operations
39. Segregation of All GA on Separate Approach Routes



LAMBERT-ST. LOUIS INTERNATIONAL AIRPORT

REVISED 7/27/90

Lambert - St. Louis International Airport
Airport Capacity Design Team Project Summary

Recommended Improvements

Airfield Improvements

1. New Runway Parallel to Runway 12L/30R
   a. Alternate 1: New Independent Commuter Runway 2500' from Runway 12L/30R
   b. Alternate 2: New Dependent Commuter Runway 1400' from Runway 12L/30R
   c. Alternate 3: New Independent Air Carrier Runway Parallel to Runway 12L/30R
2. Convert Taxiway F to Permanent VFR Runway 13/31
3. Angled Exits on Runway 12L/30R (Not Pictured)
4. Taxiway Extensions
   a. Extend Taxiway A-South to End of Runway 30L
   b. Extend Taxiway P from Taxiway C to Taxiway M (Not Pictured)
   c. Extend Taxiway C from Taxiway F to Runway End 24
5. Realign Taxiway B off A to Runway 12R/30L (Not Pictured)
6. Establish Queuing Areas to Various Runway Ends (Not Pictured)
7. Relocate Cargo Area (Not Pictured)
8. Relocate Mid Coast Aviation to Northeast (Not Pictured)

Facilities and Equipment Improvements

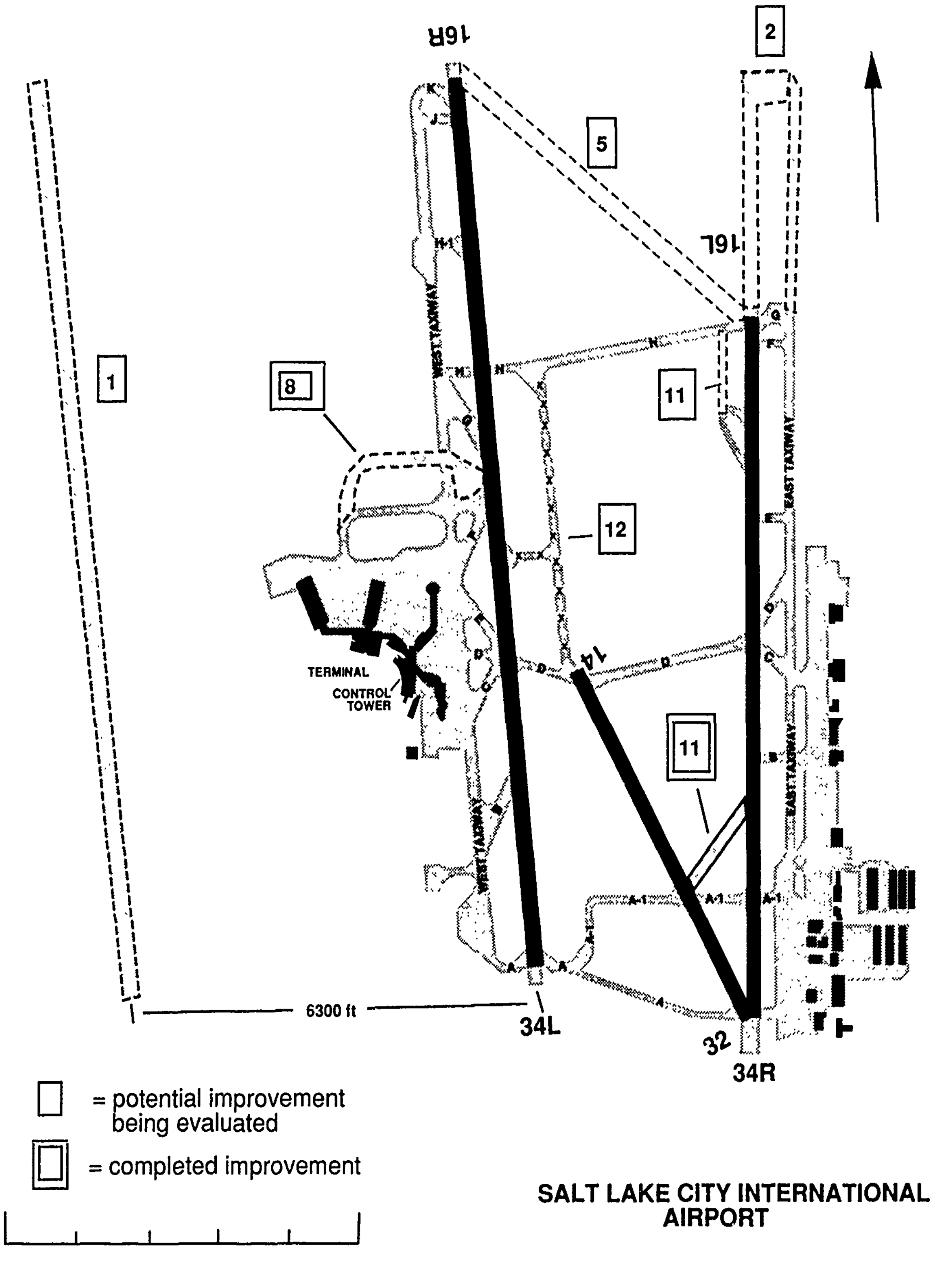
9. Install Marker Lights and Parking Lanes in Center Field Remote Holding Area (Not Pictured)
10. Wake Vortex System
11. Install Cat III ILS to Reduce Approach Minima on Runways 12L and 12R
12. IFR Approaches with Additional Instrumentation on Runway 6
13. IFR Approaches with Additional Instrumentation (RAIL) on Runway 24
14. LDA Approaches Support
    a. Equipment Installation on Runway 30L
    b. Equipment Installation on Runway 12L
15. Install Light Systems at Taxiway and Runway Intersection
16. Install ASDE

Operational Improvements

17. Reduce IFR Parallel Approach Stagger to 2NM
18. Reduce IFR Initial Separations to 2.5NM
19. Converging IFR Approaches to
    a. Runway 6 and 30R
    b Runway 6 and 30L
20. Converging IFR Approaches to
    a. Runways 24 and 30R
    b. Runways 24 and 30L
21. Simultaneous Approaches to ILS 30R, LDA 30L, and ILS 24

User Improvements

22. Change Fleet Mix
    a. Relocate GA 25%
    b. Relocate GA 50%
    c. Relocate GA 75%
23. Distribute Scheduled Commercial Operations Within the Hour
24. Relocate Air National Guard



SALT LAKE CITY INTERNATIONAL AIRPORT

REVISED 5-25-90

Salt Lake City International Airport
Airport Capacity Design Team Project Summary

Potential Improvements Being Evaluated

Airfield Improvements

1. New Independent Air Carrier Runway to West With CAT III on Both Ends
2. Extend 34R to 12000 Length
3. Construct Stopway on 34R (Not Pictured)
5. Crossover Taxiway Between 16L and 16R at North End
6. Relocate Tower (Not Pictured)
7. Improve Access to Cargo Terminal (Not Pictured)
8. Baseline w/Revised Exit Layout Including Twy to Delta Hangar and Extend F1 & F2 to West Boundary of Terminal (Not Pictured)
9. Staging Area for Runway End 16R and 34L (Not Pictured)
10. Effect of Terminal Expansions (Not Pictured)
11. High Speed Exits to West of 34R and 16L
12. Rehab Taxiways X & Y

Facilities and Equipment Improvements

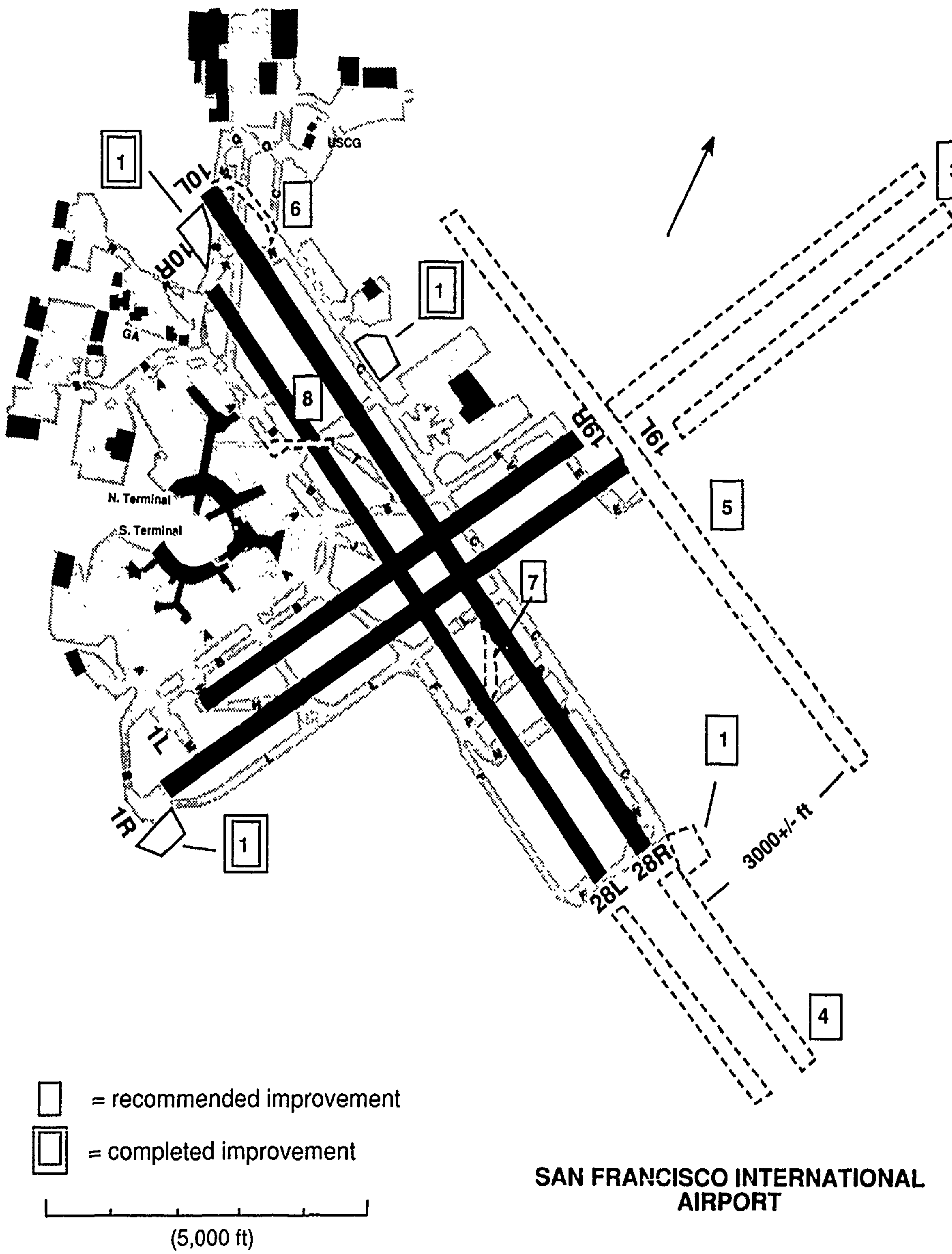
13. CAT III on 16R
14. CAT I on 34R
15. Install Precision Radar Monitoring
16. Benefit of MLS
17. Install RVR on 34R
18. Install ASDE
19. Centerline Lights on 34R
20. Install Taxiway Centerline Lights

Operational Improvements

21. Make Bonneville Routing One-Way
22. Impact of Military Airspace
23. Effect of Noise Restrictions
24. Reduce Intrail Arrival Separation Standard to 2.5 NM Between Like Class Aircraft
25. IFR Independent Converging Approaches

User Improvements

27. Reduce Runway Occupancy Times Through Pilot Education
28. Reduce General Aviation Ops During Peak IFR
29. Upgrade Reliever Airports
    a. 10% GA Relocation
    b. 20% GA Relocation
    c. 30% GA Relocation
30. Uniformly Distribute Schedule Within the Hour
31. Delta Ramp Control



SAN FRANCISCO INTERNATIONAL AIRPORT

12/22/89

San Francisco International Airport
Airport Capacity Design Team Project Summary

Recommended Improvements

Airfield Improvements

1. Create Holding Areas Near Runway 10L/R, 1R and 28R
2. Improve Noise Barrier for Runway 1R
3. Extend Runway 19L/R
4. Extend Runway 28L/R
5. Construct Independent Parallel Runway 28
6. Extend Taxiway C to Threshold Runway 10L
7. Create High Speed Exit From Runway 10L Between Taxiways L and P
8. Extend Taxiway T to Taxiway or A

Operational Improvements

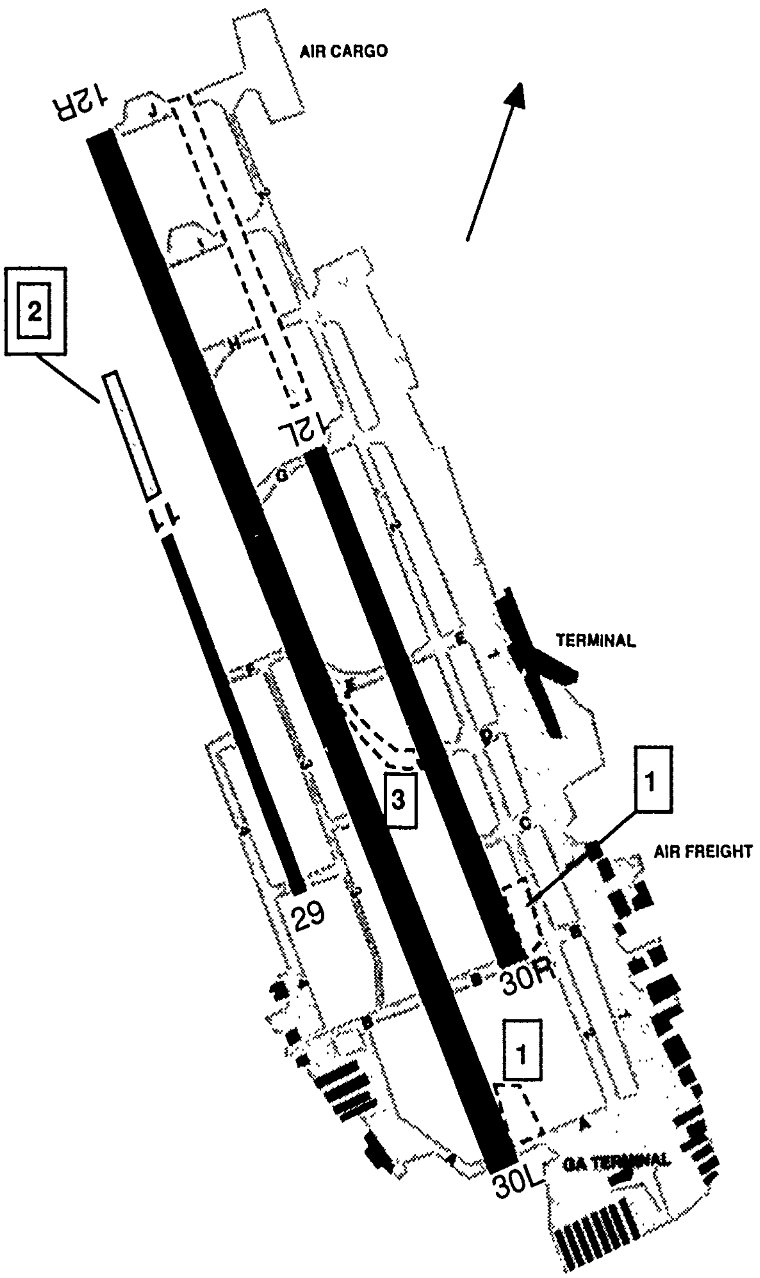
9. Expand Visual Approach Procedures
10. Offset Instrument Approach to Runway 28R
11. Use Staggered 1-Mile Divergent IFR Departures on Runway 10L/R

Facilities and Equipment Improvements

12. Install Microwave Landing System (MLS) on Runway 28 and 19

User Improvements

13. Taxi Aircraft Across Active Instead of Towing
14. Distribute Airline Traffic More Evenly Among Three Airports
15. Distribute Traffic Uniformly Within the Hour
16. Divert 50% General Aviation to Reliever Airports



= recommended improvement

= completed improvement

(5000 FT.)

SAN JOSE INTERNATIONAL AIRPORT

12/22/89

San Jose International Airport Airport
Airport Capacity Design Team Project Summary

Recommended Improvements

Airfield Improvements

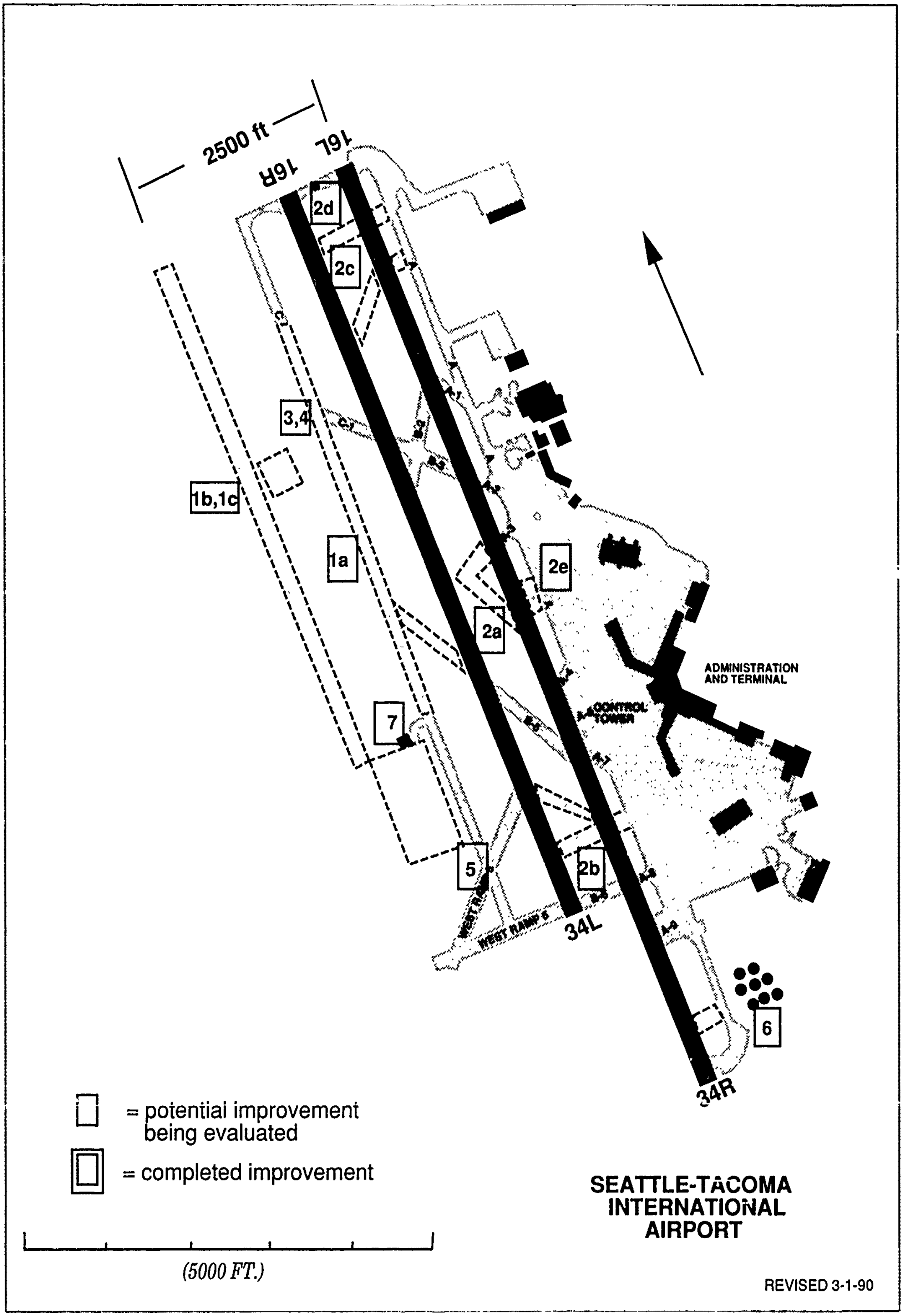
1. Create Staging Area at Runway 30L/R
2. Extend and Upgrade Runway 11R/29
3. Create Angled Exits for Runway 12R

Facilities and Equipment Improvements

4. Promote Use of Reliever ILS Training Facility
5. Install MLS on Runway 30L

Operational Improvements

6. Implement Simultaneous Departure With Moffett Field


2500 ft
16R
16L
2d
2c
3,4
1b,1c
1a
2e
2a
7
ADMINISTRATION AND TERMINAL
CONTROL TOWER
5
2b
WEST RAMP 5
34L
6
34R
= potential improvement being evaluated
= completed improvement
(5000 FT.)
SEATTLE-TACOMA INTERNATIONAL AIRPORT
REVISED 3-1-90

Seattle - Tacoma International Airport
Airport Capacity Design Team Project Summary

Potential Improvements Being Evaluated

Airfield Improvements

1. Runway alternates:
   a. Convert Taxiway D to 5000' Commuter Runway 17/35 with Associated Taxiway System
   b. Dependent Aircarrier 7000' Runway 16W/34W 2500' from 16L/34R
   c. Independent Aircarrier 7000' Runway 2500' from 16L/34R
2. Taxiway construction:
   a. Two (2) High Speed Exits at Midpoint on Runway 16R/34L
   b. High Speed (B6) and Crossover Taxiways to Apron at Runway End 34L
   c. High Speed (Exit (B-1) midway between Taxiway B and B-2 to Runway 16R/34L (No more than 600 ft. south of threshold)
   d. Crossover Taxiway to Apron at Runway and 16R
   e. New Exits Midway between TWYs A3 and A4 to Runway 16L/34R
   f. Fillets at Taxiways A1 and B2 (Not Pictured)
3. New West Commuter Terminal
4. New West Air Carrier Satellite Terminal
5. Penalty Box West of Runway 16R/34L
6. Provide Wider Runup Pads for Runway Ends 34R and 34L
7. Provide Hard Stands for Overnight Aircraft Parking
8. High Speed Exit Centerline Lights for Both North and South Flows at Exit B8 on Runway 16L/34R

Facilities and Equipment Improvements

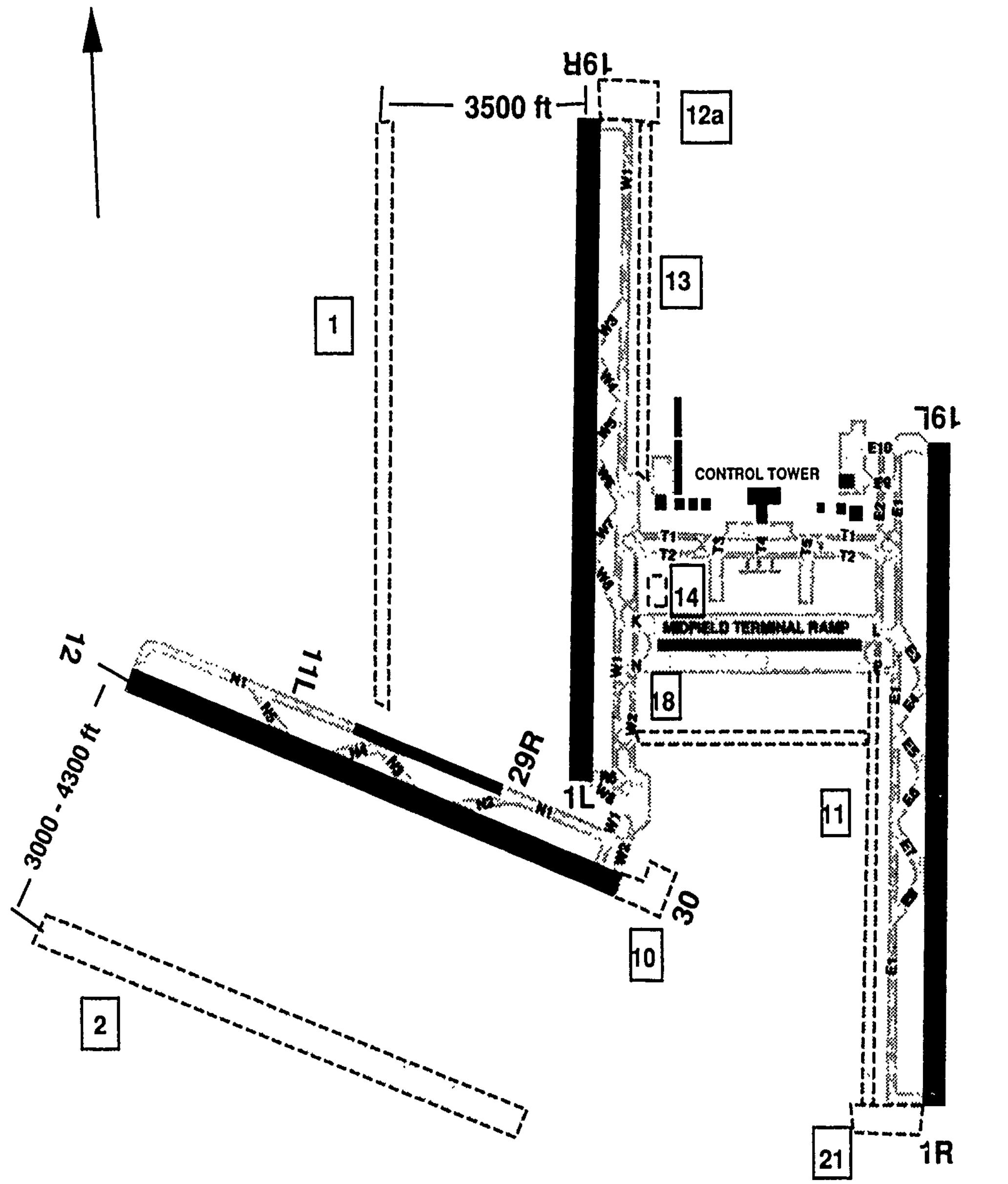
9. ILS CAT I 16L
10. ILS CAT I&II 34L
11. LDA to Runway 16R (See #17)
12. LDA to TWY D (Runway 17)
13. MLS to Runway 17
14. ILS CAT I&II Runway 16W
15. ILS CAT I&II Runway 34W

Operational Improvements

17. LDA Approaches to 16R; Taxiway C (17); 16W
18. Operate 34L as Primary Arrival Runway
19. Noise Abatement Procedure Effects on Arrivals and Departures (Install Markers for Departures)
20. Modify Noise Abatement with Percent Use Change of Stage 3 Aircraft Operations on the Airport (Fleet Mix Change)
21. Four (4) Corner Concept for Approaches (3 Routes to 4 Routes)
    SIMMOD may be used instead of ADSIM if SIMMOD application at Salt Lake City is successful
22. Fanned Departures Both to the North and to the South
23. Stagger Approaches to 34R/34W and 16L/16W — 2.0 nm stagger
25. Reduce Intrail Spacing 2.5 NM
26. Wake Vortex Advisory System for Close Spacing

User Improvements

27. Uniformly Distribute Scheduled Operations Within the Hour
28. a. Retain 50% of Commuter Operations (Implied Move to Boeing)
    b. Retain 75% Commuter Operations (Implied Move to Boeing)
29. Operation Agreement to Limit Boeing Activity During Rush Critical Periods
30. Provide Attractive Alternate Facilities for Short Haul Air-carriers at Other Airports



□ = potential improvement being evaluated

▣ = completed improvement

WASHINGTON/DULLES INTERNATIONAL AIRPORT

(5,000 ft)

Revised 7/23/90

Washington Dulles International Airport
Airport Capacity Design Team Project Summary

Potential Improvements Being Evaluated

Airfield Improvements

1. Add Runway 1W/19W—Long 3,500' From Runway 1L, Full ILS
2. Add Runway 12R/30L—10,000' Long, 4300' From Runway 12/30, Full ILS
3. Add GA Runway(s) West of Runway 1L (With Increased GA Traffic) (Not Pictured)
4. Widen Turnback Fillets to Runway 1L (at Exits W-3, W-5) (Not Pictured)
5. Widen Turnback Fillets to Runway 19L (at Exits E-6, E-8) (Not Pictured)

5 a. Construction at R-2 (Not Pictured)

8. Add GA Exit to Runway 19R (North of Exit W-3) (Not Pictured)
9. Add GA Exit to Runway 19L (North of Exit E-3) (Not Pictured)
10. Extend Runway 12/30 SE Taxiway
11. Add Runway 1R Holding Pad and Extend Taxiway E-2 South (to Approach End of 1R)

12a. Add Runway 19R Holding Pad (or By-Pass) and Extend Taxiway W-2 North

12b. Add 19R Bypass (Not Pictured)

14. Add Midfield Ramp
15. Add Centerfield North/South Taxiway (May Reduce # of Gates) (Not Pictured)
    — Escape Mechanism if Someone is in Pushback
    — Base of Phase 1A and Phase 1B
16. Phase 1A — 1st Phase Midfield (24 Gates and N/S Taxiway) (Not Pictured)
    — Base for Phase 1B
17. Phase 1B — Add Midfield Terminal (48 Gates and N/S Taxiway) (Not Pictured)
    — Includes 24 Gates in Phase 1A
18. Add East/West Taxiway R-3 (South of R-2)
19. Additional FBO to East of Runway 19R Threshold (Not Pictured)

Facilities and Equipment Improvements

20. RVR 1L
21. RVR 12/30 (waiver required)
22. Centerline Lights on 12/30

Operational Improvements

23. Simultaneous Approach 1's and 19's
24. Simultaneous Converging Instrument Approaches 12 & 19's (Dual Arrivals)
25. Simultaneous Converging Instrument Approaches 12 & 19's (Trip Arrivals)
26. 2.5 NM Longitudinal Spacing Inside Outer Marker (2.5 vs. 3 for non-heavy A/C) — Base for All Runs

User Improvements

27. Uniformly Distribute Traffic Within the Hour
28. Reduce GA Traffic by Use of Reliever Airports (10%, 25%, 50%)
29. Reduce Occupancy Times

Appendix C

New Runway Construction Projects at Major U.S. Airports

Introduction

This appendix provides supporting material for Chapter 2.

Tables 2-2 and C-1 present information on the new construction projects proposed and in progress at the top 100 airports. Table 2-2 presents known new construction improvements proposed and in progress at the top 100 airports, as well as construction projects recommended by airport capacity design teams (or task forces), that may still be in the early planning stage. Table C-1 contains only those known new construction projects proposed and in progress as reported by the nine FAA Regional Offices in June 1990.

From information received from the FAA Regional Offices, approximately two-thirds of the 100 airports dealt with in this plan are in various stages of development and construction involving new runways or runway extensions. Five other airports have also recommended construction as a result of airport design teams. Table 2-2 reflects all such projects. Table C-1 reflects only those projects as reported by the FAA Regional Offices. The specific description for each individual airport accompanying the airport layout states if the proposed project is a result of a design team recommendation.

The column headings in Table C-1 reflect the progress for each project. The dates are shown if the project is in the Airport Layout Plan (ALP), if an Airport Improvement Program (AIP) grant application has been submitted, if an Environmental Impact Study (EIS) has been scheduled, if there is a known cost for additional land acquisition, and if the construction has been scheduled to begin. Also shown is the estimated cost and operational date.

Table C-1. New Construction Database.

Region	Airport ID	Project	In ALP	AIP	EIS	Land Cost	Start Date	$M Est.	Op. Date
ASO	BHM	Extend Runway 18/36 FROM 4,856' to 7,500'	3/88		7/89	No		$42.50	
ANM	SEA	Construct new Runway 16/34 West							
AWP	TUS	11R/29L New Air Carrier Runway						$143.00	
AWP	SJC	Runway 30R/12L Extension	4/88				1/91	$10.00	
ASW	DFW	Extend Runway 17R/35L	2/85	7/90	2/90		1/91	$24.00	
ASW	DFW	Extend Runway 18L/36R	2/85	7/90	2/90			$24.00	
AWP	LAX	Runway 6L/24R Extension						$4.00	
AEA	JFK	Runway 4L/22RExtension	9/88						
AEA	EWR	Runway 11/29 500' Extension	7/89						
AEA	ISP	Runway 6/24 1,000' Extension	12/80						
AEA	PHL	Proposed new commuter Runway 8/26 (5,000')	6/91					$100.00	
AEA	PHL	Relocate Runway 9L/27R 9,000'	6/91						
ASO	JAX	Construct parallel Runway 7R/25L 6,500' from exsisting Runway 7/25	5/87					$37.00	
ASO	PBI	Extension Runway 9L/27R on both ends	6/79			Yes		$3.50	
ASO	GSP	Parallel Runway 3R/21L (5,900' x 100')	9/87						
AWP	OAK	11R/29L new air carrier runway						$143.00	
ASO	CAE	Extend Runway 5/23	9/89	5/88	3/87		6/88	$14.50	Apr-90
AGL	IND	Construct Runway 5R/23L	2/78	5/88	3/88		5/88	$44.60	Jul-90
AEA	BWI	Extend Runway 15L/33R and construct associated taxiways	12/87	8/89	7/89	Yes	8/89	$10.50	Jul-90
ASW	ABQ	Extend Runway 3/21	4/88	9/88			8/89	$11.10	Jul-90
AGL	CLE	Reconstruct Runway 5R/23L	2/85	3/90			4/90	$16.50	Oct-90
AGL	DTW	Extend Runway 3L/21R	3/90	5/90	9/89		6/90	$7.30	Oct-90
ASO	CVG	Construct Runway 18L/36R	1/90		5/88		10/88	$97.00	Dec-90
AGL	MSP	Runway 4/22 Extension	3/90	1/91			1/91	$11.00	Jan-91 *
AWP	LAS	Runway 7R/25L	4/89				1/91	$42.00	Jan-91 *
ASW	MSY	Runway 10/28 extension - 10,039' upon completion	9/86		6/86			$10.00	Jul-91
ASW	LIT	Runway 4R/22L	5/90	9/82	8/81		12/83	$80.00	Jul-91
ASO	BNA	Extend Runway 2L/20R	9/90	9/90		Yes	4/91	$39.80	Jul-91
AGL	DTW	Construct Runway 9R/27L	3/90	1/91	9/89		10/90	$69.10	Dec-91
AEA	IAD	Extend Runway 12/30	2/88	1/91			1/91	$7.20	Jan-92 *
AEA	BUF	Runway 14/32 extension and threshold relocation	4/90	8/91	6/88	Yes	5/92	$4.00	Jan-92 *

* Undetermined date within calendar year.

Table C-1. New Construction Database (continued).

Region	Airport ID	Project	In ALP	AIP	EIS	Land Cost	Start Date	$M Est.	Op. Date
ASW	MAF	Extend Runway 10/28	8/81	5/91	6/90		6/91	$5.80	Mar-92
ANM	COS	Construct new Runway 17L/35R	1/89	7/91			8/90	$38.00	Jun-92
AGL	MKE	Extend Runway 1L/19R 2,000' and bridge College Ave.	6/90	6/91			8/91	$13.00	Aug-92
ASO	RSW	Extend Runway 6/24	8/88	8/91			11/91	$10.00	Sep-92
ASO	SDF	Construct East Parallel Runway 17L/35R	9/90		5/90	No	3/91	$250.00	Sep-92
ASO	TYS	3,000' Runway 5R/23L Extension	1/88	9/88	7/88		6/89	$17.40	Sep-92
ASO	CLT	Runway 36R/18L Extension	3/88		4/89		10/90	$6.80	Oct-92
ACE	MCI	New N/S Parallel Runway 1R/19L (9,500' x 150')	12/81	9/88	10/81		10/89	$46.20	Nov-92
ASW	DFW	Construct Runway 16L/34R (East side)	2/85			Yes	1/92	$100.00	Jan-93 *
ASO	MCO	Construct 4th Runway 17L/35R (10,000' x 150')	12/89	10/92				$80.00	Sep-93
ANM	DVX	Construct New Airport	9/89	9/89	8/89		9/89	$2,500.00	Oct-93
AGL	CMH	Extend Runway 10L/28R 1,000'		1/92			4/93	$8.10	Dec-93
AGL	GRR	Construct Runway 8L/26R	3/84	8/91			4/92	$25.00	Dec-93
AWP	PHX	Runway 8S/26S Third Parallel		1/92				$88.00	Jan-94 *
AEA	ROC	Runway 10/28 Extension	8/90	1/92		Yes	5/93	$2.30	Jan-94 *
ASO	RSW	Construct New Air Carrier Runway 6L/24R	8/88	10/92		Yes	11/92	$47.00	Sep-94
ASO	ATL	Construct Fifth Parallel Runway	3/92	3/92		Yes	6/92	$130.00	Sep-94
ASO	MEM	Construct Runsway 18L/36R	6/90			Yes	4/91	$105.10	Oct-94
AEA	ORF	Construct New Runway 5R/23L	5/83	1/92		No		$13.00	Nov-94
ANM	SLC	Construct New Runway 16/34 West	1/89	1/91			4/91	$95.00	Nov-94
AGL	CMH	Extend Runway 10R/28L 1,000'		1/93			4/94	$3.20	Dec-94
ASO	SAV	Extend Runway 18 (1,000')	1/93	1/93			1/94	$3.90	Jan-95 *
ASW	MSY	Parallel Runway 10/28				Yes	1/93	$40.00	Jan-95 *
ASW	AUS	New Austin Airport — Construct Runway 17L/35R and 17R/35L			5/90	Yes	5/91	$550.00	Feb-95
ASW	LBB	Extend Runway 8/26	7/81	6/93			3/94	$6.20	Jun-95
ASW	HRL	Extend Runway 13/31 from 7,255' to 9,500'	8/90	1/92		Yes	4/94	$6.70	Jun-95
ASW	HRL	New Parallel GA Runway 13L/31R 100' x 5,000'	8/90	1/92		Yes	4/94	$5.00	Jun-95
AGL	IND	Construct Runway 5L/23R (Replacement)	10/90	12/92			6/93	$42.00	Jun-95
ASO	FLL	Extend Runway 9R/27L to (6,000' x 150')	1/89	6/94			9/94	$26.00	Jun-95
AEA	PIT	Construction of Parallel Crosswind Runway 14R/32L	3/82	8/92			6/93		Sep-95
AEA	PIT	Construction 4th Parallel 10/28	12/91	8/92			6/93		Sep-95

* Undetermined date within calendar year.

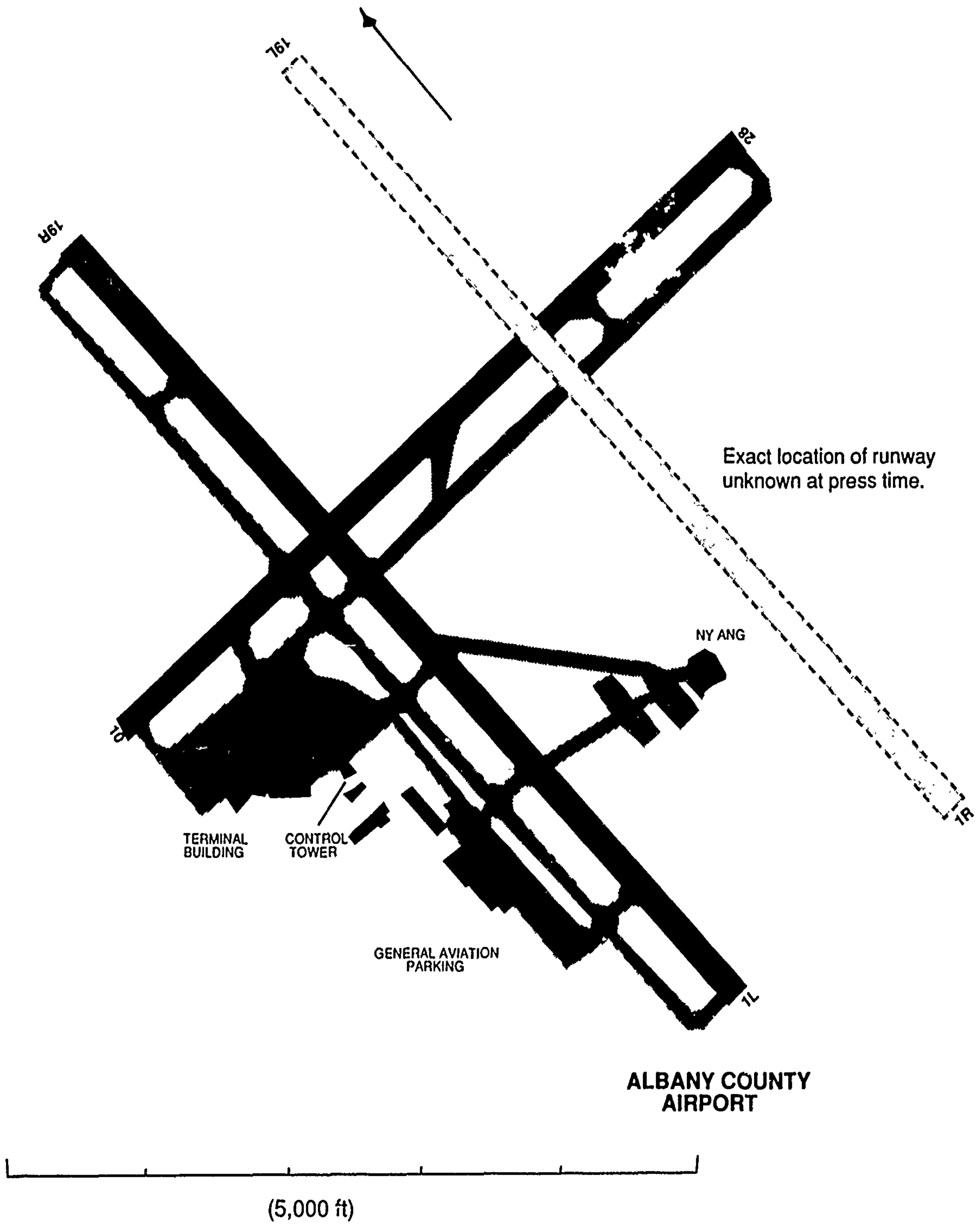
Table C-1. New Construction Database (concluded).

Region	Airport ID	Project	In ALP	AIP	EIS	Land Cost	Start Date	$M Est.	Op. Date
ASO	SDF	Construct West Parallel Runway 17R/35L	9/90		5/90	No	3/91	$250.00	Sep-95
AGL	DTW	Construct Runway 4/22	3/90	2/94		Yes	4/94	$58.20	Dec-95
ANM	GEG	Construct New Runway 3L/21R	12/87		4/87		1/95	$11.00	Jan-96 *
AEA	ROC	Parallel Runway 4R/22L	8/90	8/94		Yes	5/95	$4.70	Jan-96 *
AEA	ROC	Runway 4/22 Extension	8/90	8/94		No	5/95	$0.50	Jan-96 *
ASO	RDU	Relocated Runway 5R/23L and Associated Taxiways	7/91	3/92			3/93	$45.00	Apr-96 *
AEA	BWI	Construct new Runway 10R/28L and Associated Taxiways	12/89	1/94		Yes	4/94	$38.00	Oct-96
AEA	ORF	Extend Runway 14/32	5/83	1/95				$2.00	Oct-96
ASW	DFW	Construct Runway 16R/34L (West side)	7/90			Yes	1/93	$95.00	Jan-97
ASW	IAH	Extend Runway 14R/32L by 2,000' to 8,038'	11/83	10/95			1/96	$8.00	Jan-97 *
AEA	ALB	Runway 10/28 Extension	8/90	9/95		Yes	5/96	$2.00	Jan-97 *
AEA	SYR	Parallel Runway 10L/28R	4/78	8/95		Yes	5/96	$5.00	Jan-97 *
ASO	TPA	Construct 3rd Parallel Runway 18R/36L (9,650' x 150')	3/90				8/95	$53.00	Jun-97
AEA	IAD	Construct Runway 1W/19W	2/88	1/96			1/99		Jan-98 *
ASO	CLT	Third Parallel Runway	3/88	1/96			1/96	$27.10	Jun-98
ASW	TUL	Parallel Runway 17/35	8/80	10/93		No		$100.00	Jul-98
ASO	GSO	Extend Runway 14/32 (1,200')	7/90				6/95	$14.00	Oct-98
ASW	IAH	New Runway 8L/26R	11/83	10/96		Yes	1/97	$44.00	Jan-99 *
ASW	MSY	Parallel Runway 1/19	9/86			Yes	1/95	$160.00	Jan-2000 *
ASW	OKC	Extension of Runway 17L/35R	1/89	7/96				$24.00	Oct-2001
ASW	OKC	Extension of Runway 17R/35L to 12,500'	1/89	7/94				$20.00	Oct-2001
ASW	OKC	17/35 10,700' Parallel; 1600' West of 17R/35L	1/89	7/96				$55.00	Oct-2001
ASW	IAH	New Runway 9R/27L	11/83	10/98			1/99	$44.00	Jan-2002 *
AEA	ALB	Parallel Runway 1R/19L	9/90	9/05		No	5/06	$15.00	Jan-2007 *
ASO	SAV	New Runway 9L/27R (9,000')	3/89	1/09			1/09	$20.00	Jan-2010 *
ASO	GSO	Parallel Runway 5/23 (7,000')	7/90	1/10			6/10	$20.00	Jan-2010 *

* Undetermined date within calendar year.

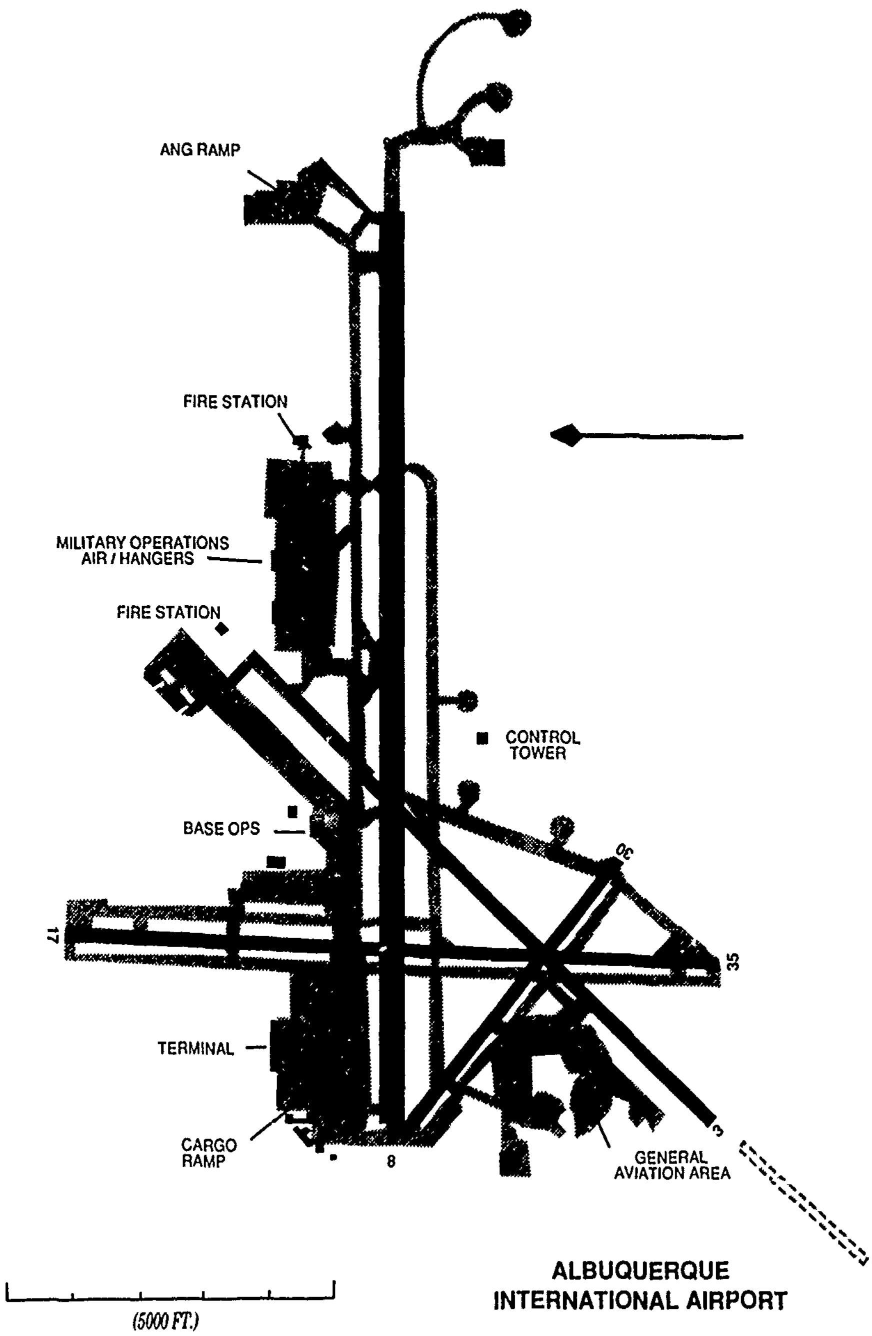
Albany (ALB)

An extension to Runway 10/28 is expected to begin in 1996 and should be completed sometime in 1997. The cost of constructing the extension is estimated to be $2 million. Albany is also planning a new parallel Runway 1R/19L to be operational in 2007. Cost of construction, scheduled to begin in 2006, is estimated to be $15 million.



Albuquerque (ABQ)

A 3,200 foot extension to Runway 3/21 is underway. The work will provide an 8,800 foot runway, eliminating the intersection with Runway 8/26. Construction started in August 1989. The expected date of completion is 1991. The cost of the runway and parallel taxiway is estimated to be $11 million.

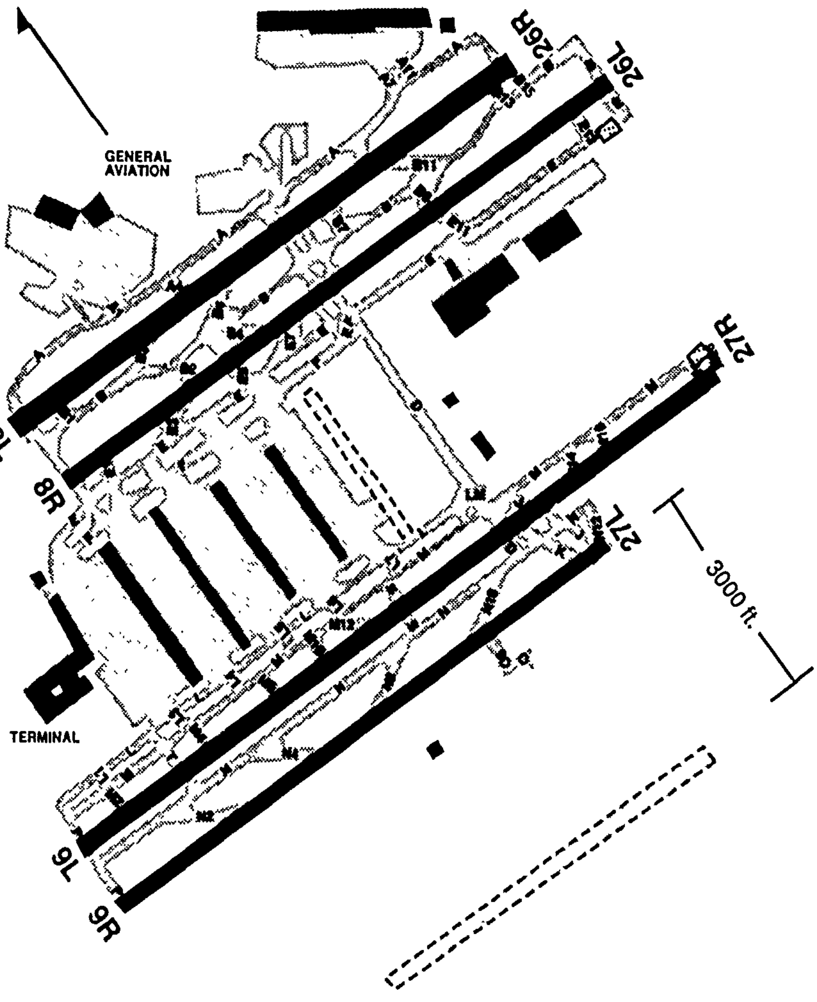


ALBUQUERQUE INTERNATIONAL AIRPORT

Revised 7/06/90

Atlanta (ATL)

A fifth parallel runway, 5,500 feet long and 3,000 feet south of Runway 9R/27L, is being planned at Atlanta. The total estimated cost is $130 million. Construction is estimated to start in 1992, and the estimated operational date is 1994.



ATLANTA - HARTSFIELD INTERNATIONAL AIRPORT

(5000 FT.)

REVISED 7-26-90

Austin (AUS)

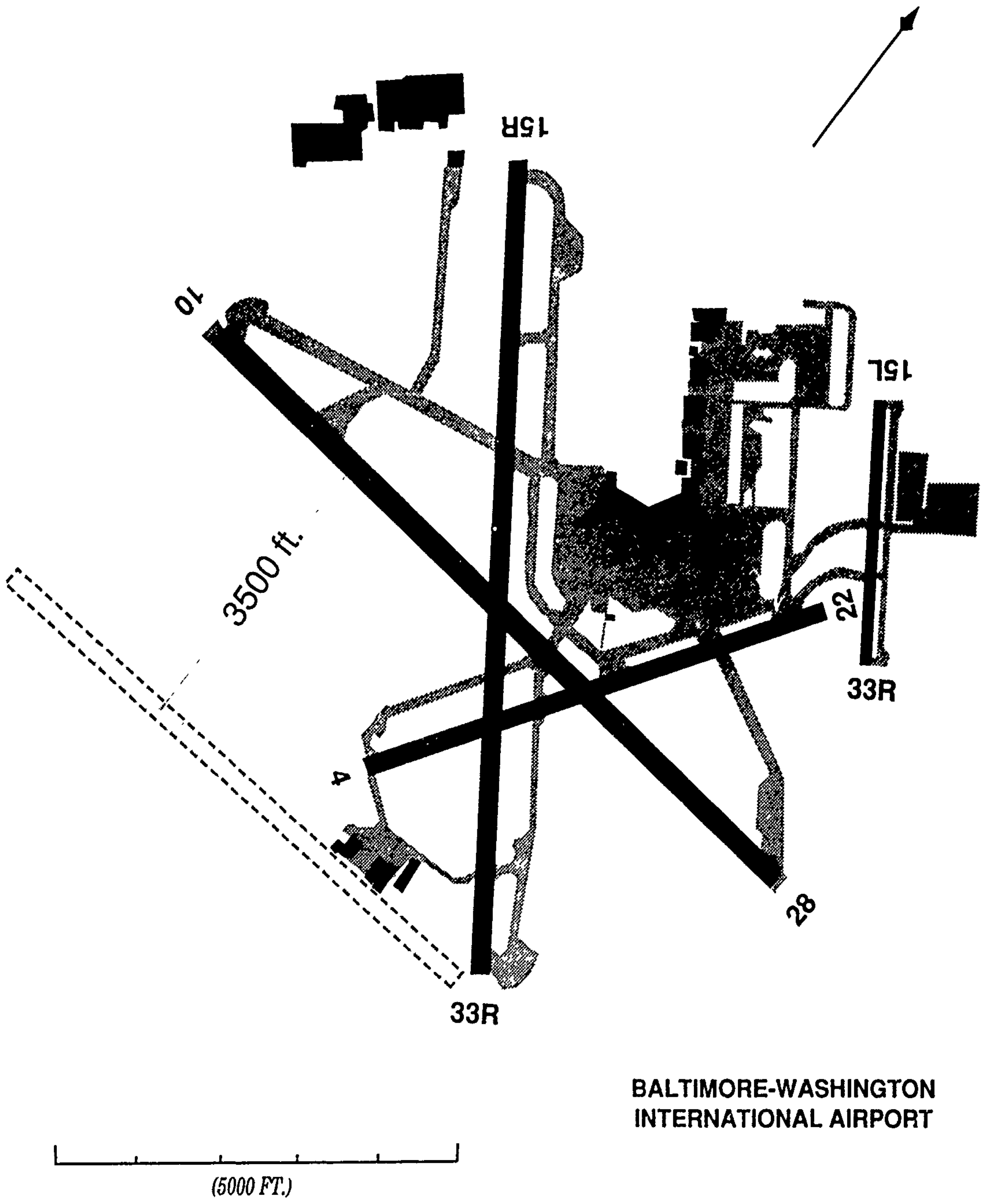
The community has approved the sale of revenue bonds for the development of a new airport. The environmental assessment for the new airport site has been approved. The present airport cannot be expanded. The new airport site will accommodate dual parallel runways that support simultaneous instrument approaches, which will potentially double the IFR arrival capacity from 26 (at Robert Mueller Airport) to 52 per hour. The estimated start date for construction is May 1991. The cost of construction of phase 1 of the new airport, including the land, terminal and two runways, is $550 million. The estimated operational date is February 1995. Since Robert Mueller Airport will close upon completion of the new airport, no capacity enhancements are planned at Mueller.

Development activities have recently been suspended pending a decision by the Air Force regarding the closing of Bergstrom AFB. Should Bergstrom AFB close, it could potentially be available for development as a civil airport for the Austin area.

An airport layout for the new Austin airport was not available at the time of publication.

Baltimore-Washington (BWI)

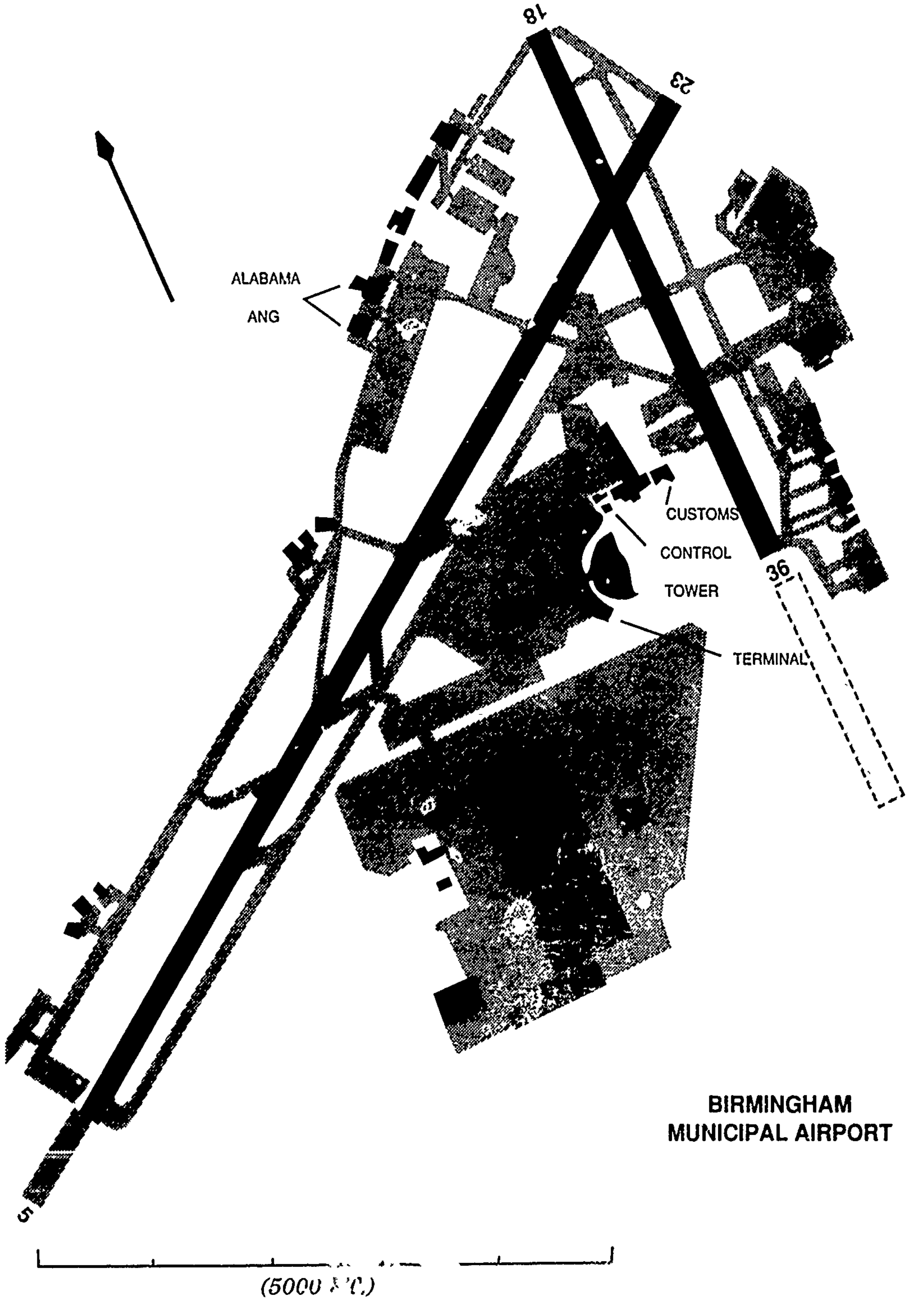
A new 7,800-foot runway, Runway 10R/28L, will be constructed 3,500 feet south of Runway 10/28. Construction is expected to begin in 1994, and the runway is planned to be completed in 1996 at a cost of $38 million. When Runway 10R/28L is constructed, Runway 4/22 will convert to a taxiway. A runway extension of Runway 15L/33R to 5,000 feet long and 100 feet wide, is estimated to be operational in 1990.



BALTIMORE-WASHINGTON
INTERNATIONAL AIRPORT

Birmingham (BHM)

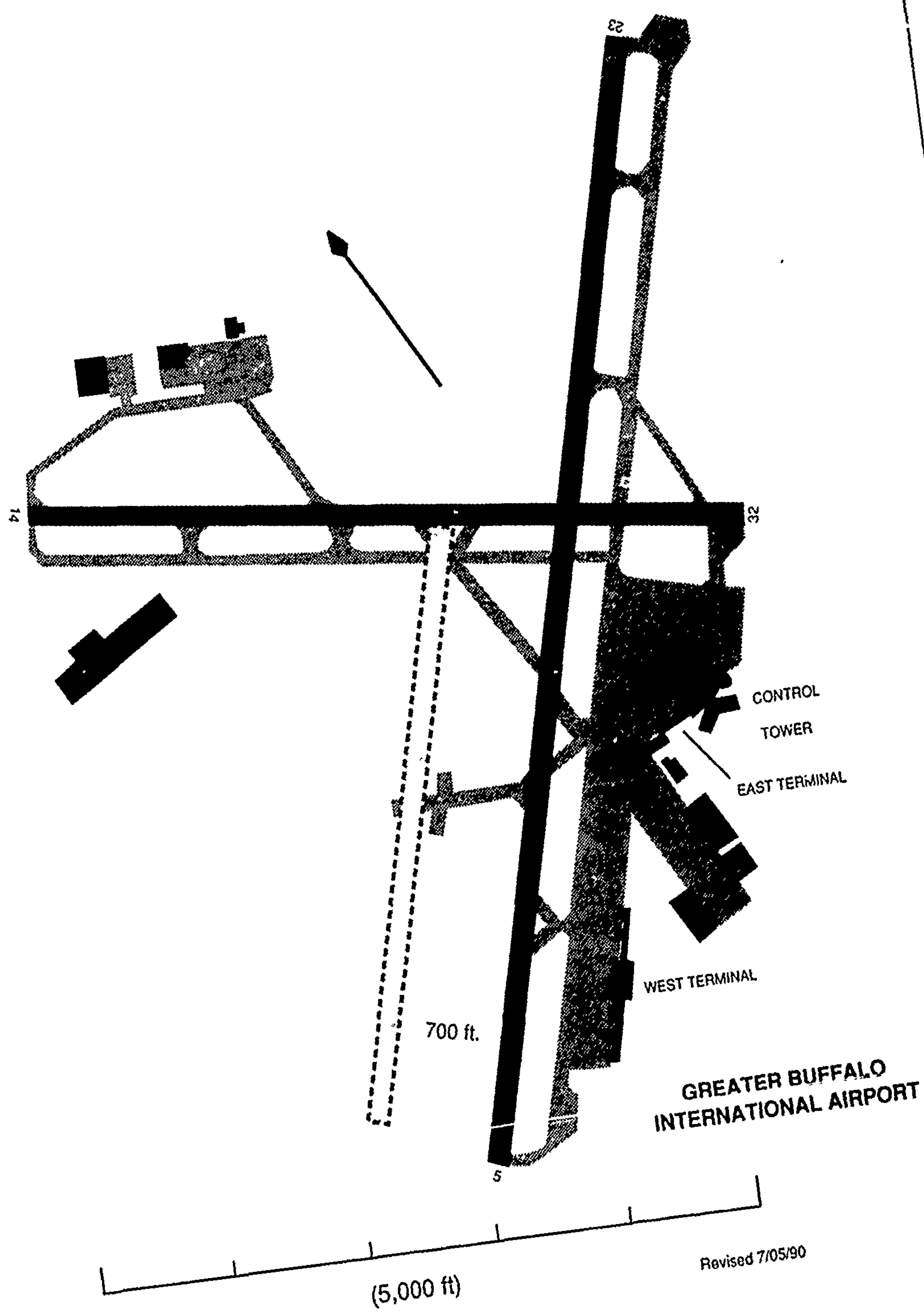
Runway 18/36 will be extended from 4,800 feet to 7,500 feet. The environmental process was completed in May 1990. The estimated cost of construction is $42.5 million.



Revised 7/27/90

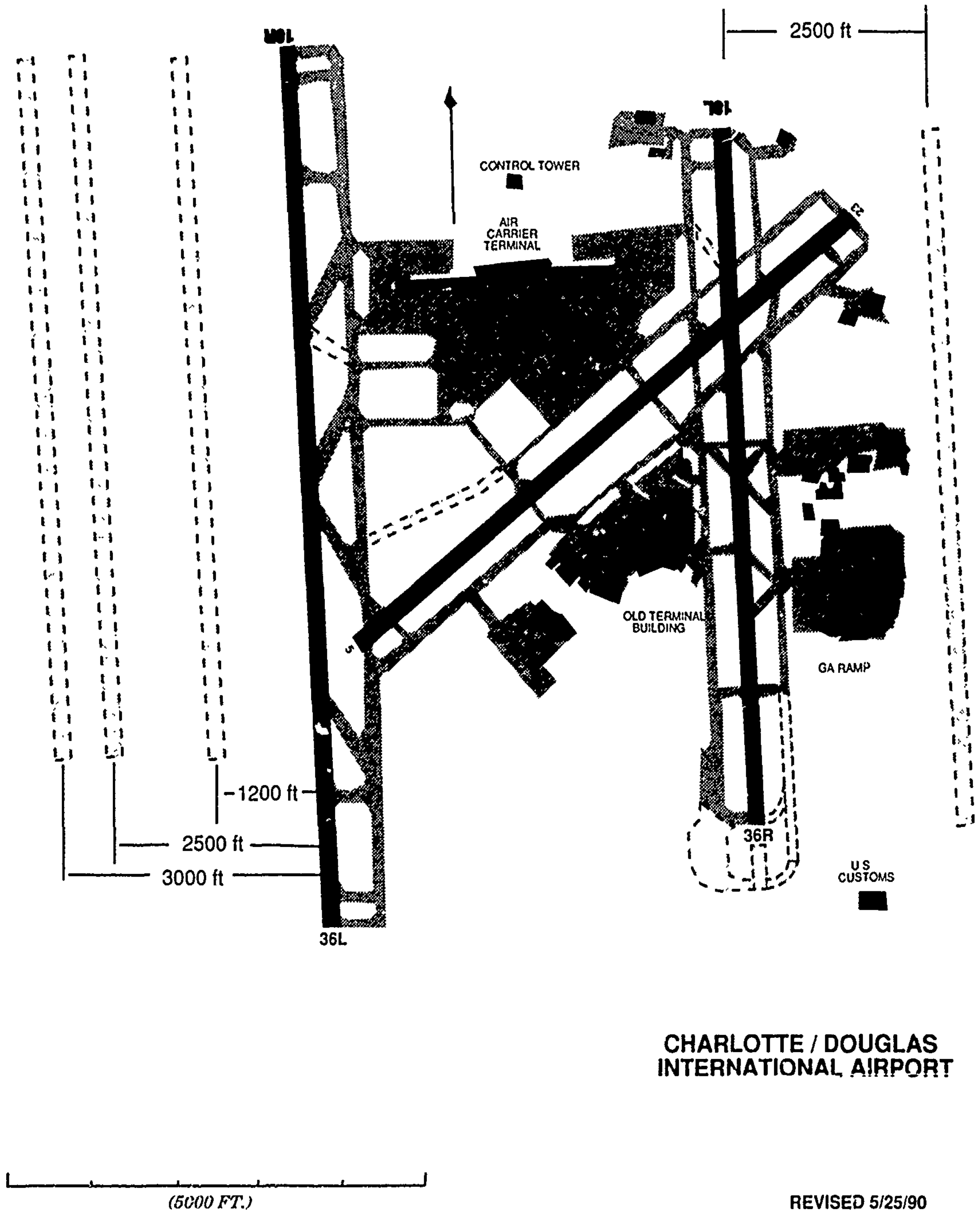
Buffalo (BUF)

A draft Master Plan shows a new parallel runway, Runway 5L/23R, 3,800 feet by 75 feet, located 700 feet northwest of Runway 5/23. It is planned for 1999-2000. No increase in IFR arrival capacity will be provided, but departure capacity will increase.



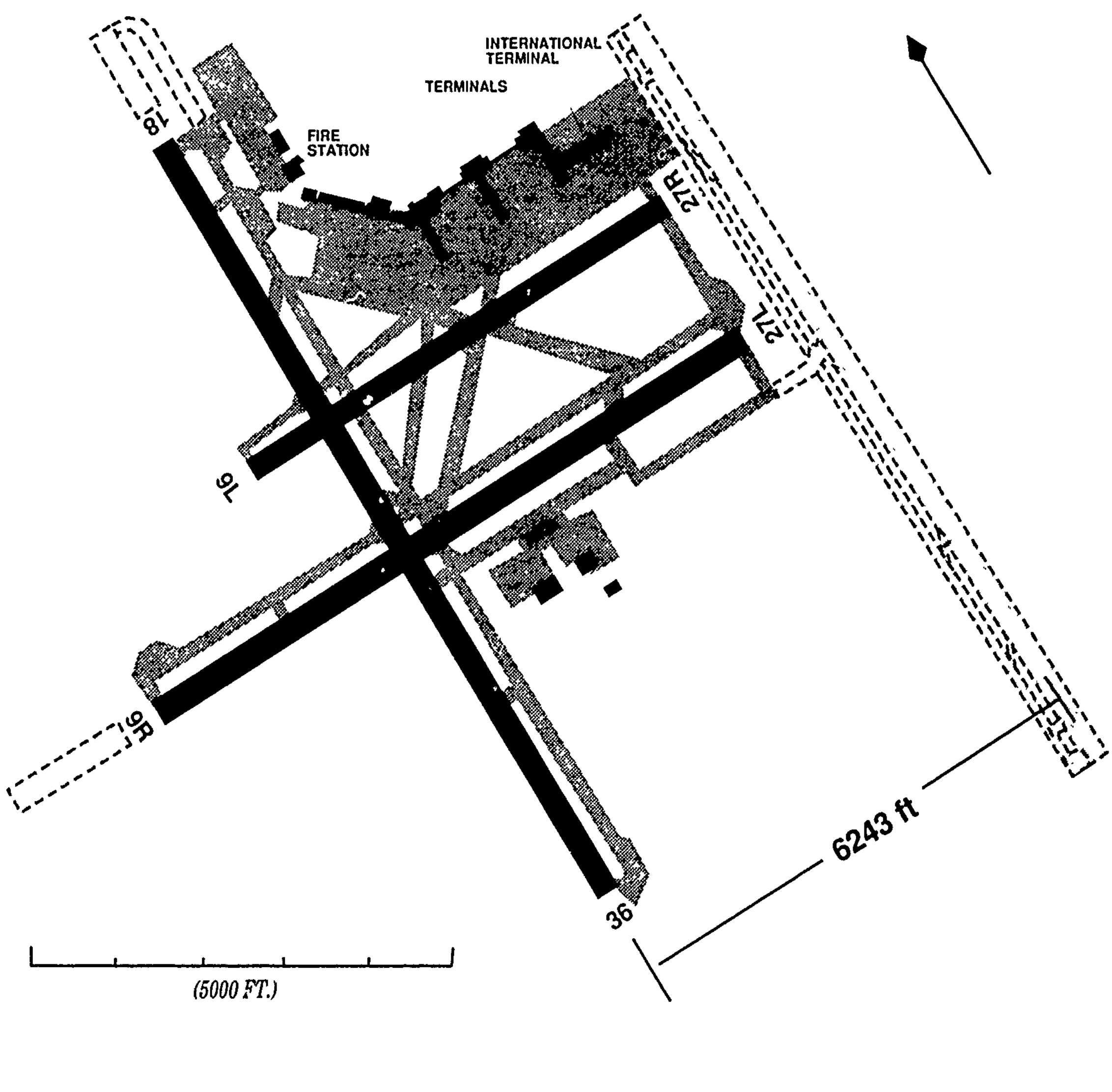
Charlotte (CLT)

Construction is scheduled to begin in October 1990 to extend Runway 36R 1,000 feet south to provide simultaneous approach capability during noise abatement hours (11 p.m. to 7 a.m. and school days). A third parallel 8,000 foot runway west of Runway 36L is being planned for 1998 that would permit independent IFR arrivals. The task force may also recommend another parallel runway east of 18L/36R. Triple or quadruple IFR approaches could become available.



Cincinnati (CVG)

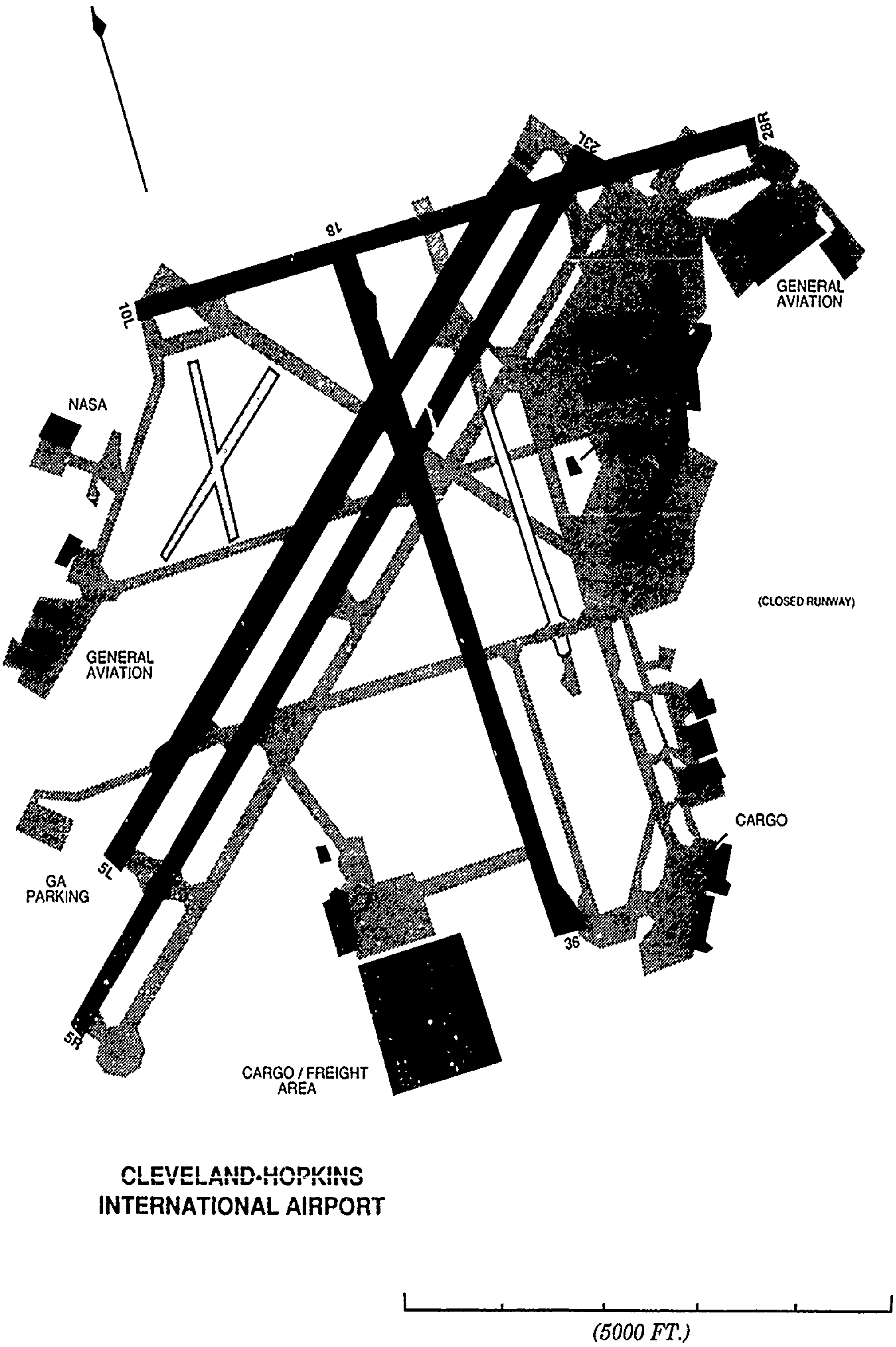
A new runway, Runway 18L/36R, parallel to and 6,200 feet away from the existing Runway 18/36, is underway for CVG. This runway will have the potential for allowing independent IFR parallel operations, doubling IFR arrival capacity. Construction began in October 1988, and the new runway is estimated to be operational in 1990. The estimated cost for the runway and the associated taxiway and roadways is approximately $97 million.



COVINGTON/GREATER CINCINNATI
INTERNATIONAL AIRPORT

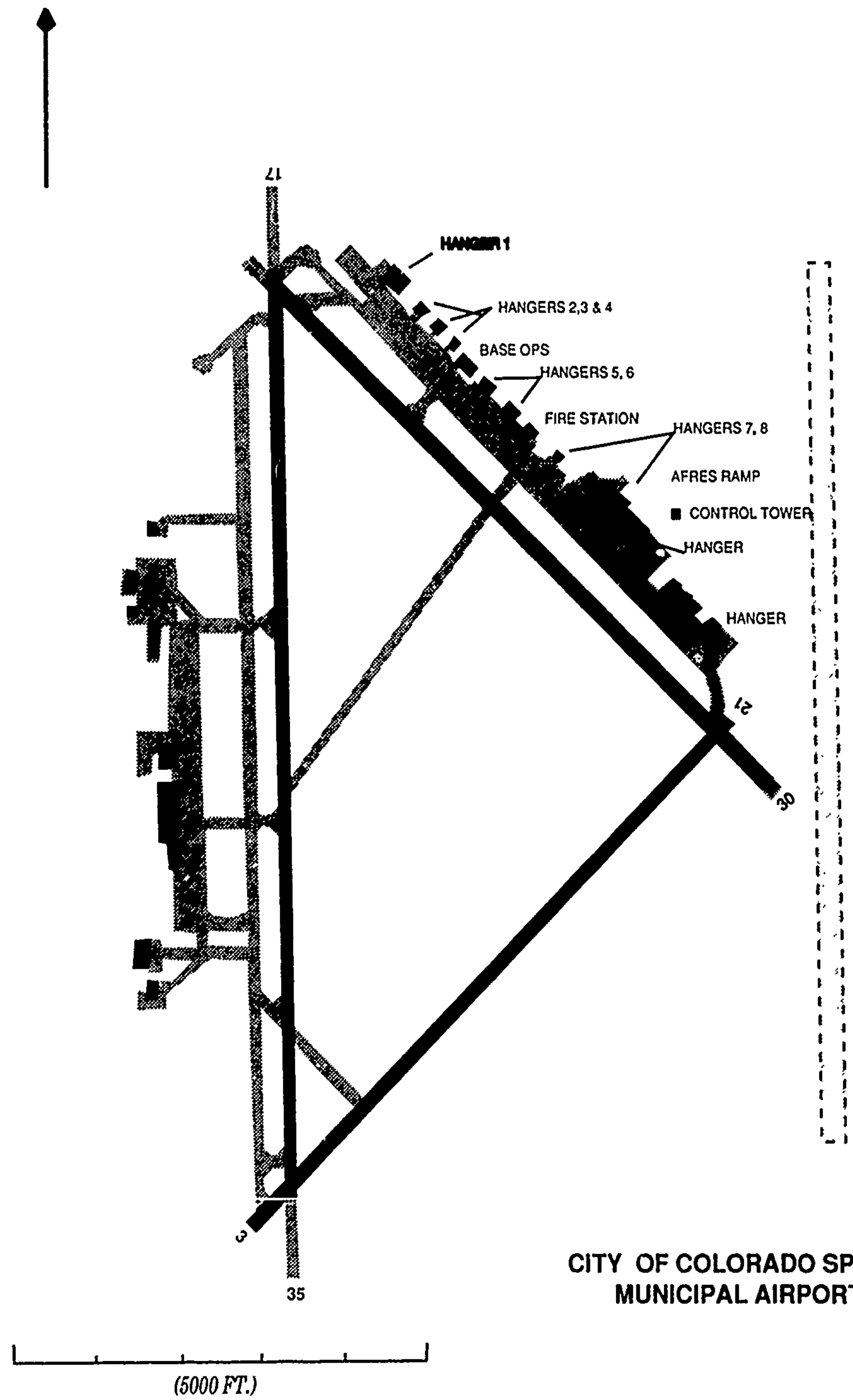
Cleveland (CLE)

The reconstruction of Runway 5R/23L began on 23 April 1990. It is expected to be complete in 1990 at a total estimated construction cost of $16.5 million.



Colorado Springs (COS)

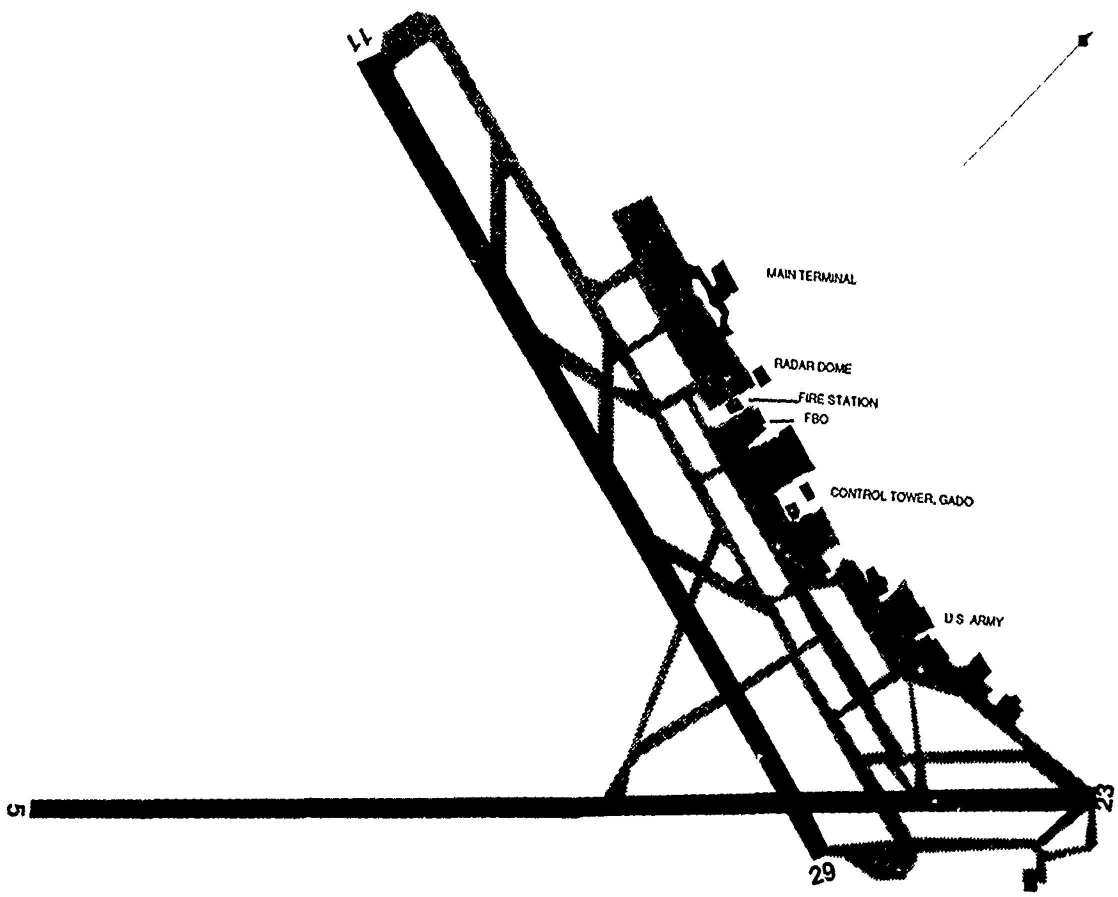
Runway 17L/35R will be constructed 8,600 feet east of existing Runway 17/35. This should permit two instrument approaches during IFR conditions, doubling arrival capacity. Construction is scheduled to begin in 1990. The runway is scheduled to be operational in 1992, at a construction cost of $38 million.



CITY OF COLORADO SPRINGS
MUNICIPAL AIRPORT

Columbia (CAE)

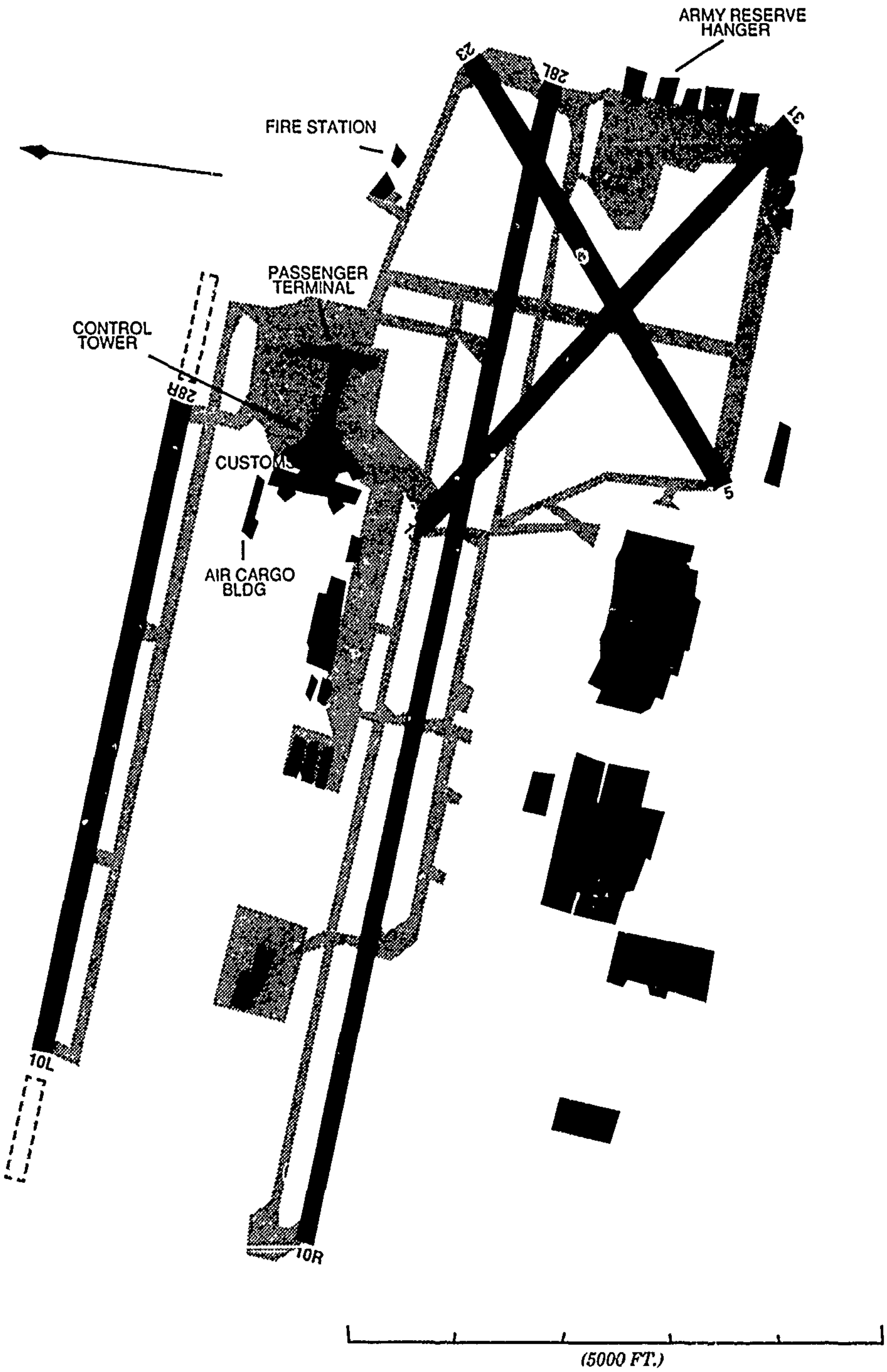
Runway 23 has been extended 7,000 feet to the southwest to a length of 12,000 feet. The runway was opened with the extension on April 26, 1990. The cost of construction was $14.5 million. If dependent converging approaches become authorized, IFR capacity could increase from 26 to 36 arrivals per hour.



COLUMBIA METROPOLITAN AIRPORT

Columbus (CMH)

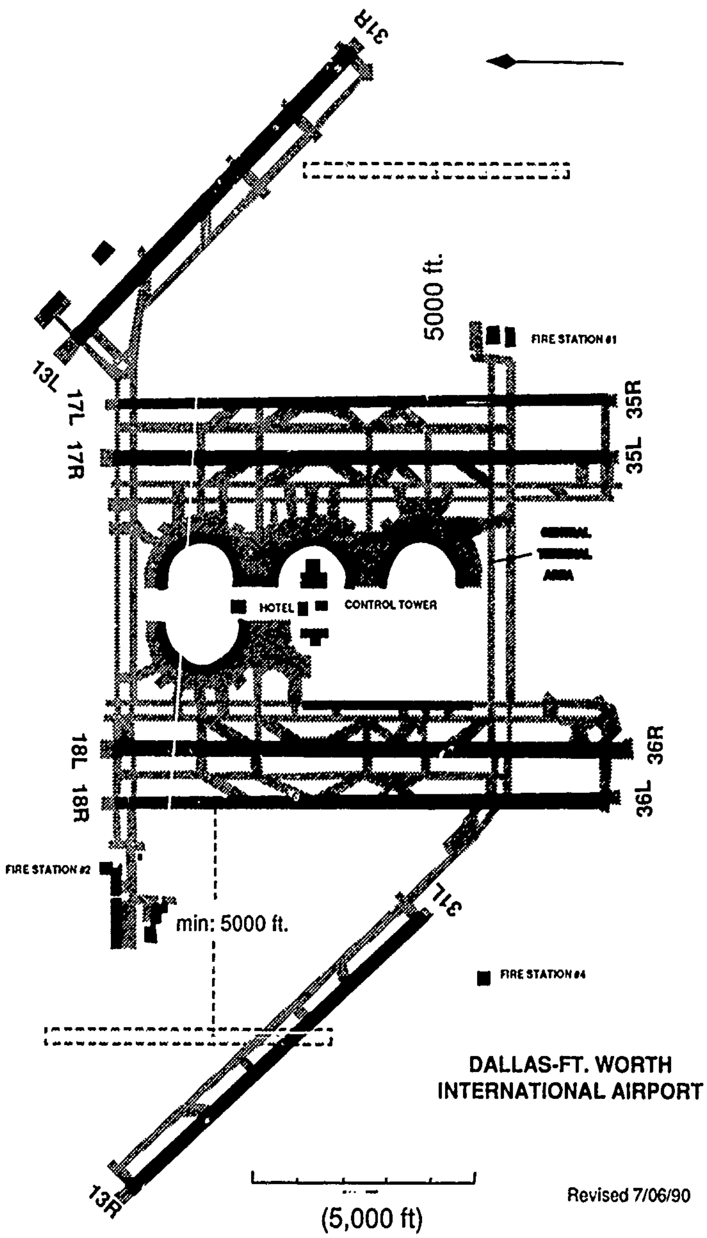
An update to the current ALP is being coordinated. It includes 1,000-foot extensions to each end of Runway 10L/28R. Construction on the extension to Runway 10L is expected to begin in early 1993 and should be completed in late 1993. The estimated cost of construction is $8.1 million. The extension to Runway 28R is expected to begin in early 1994, and be operational in late 1994. The estimated cost of construction of this extension is $3.2 million.



PORT COLUMBUS INTERNATIONAL AIRPORT

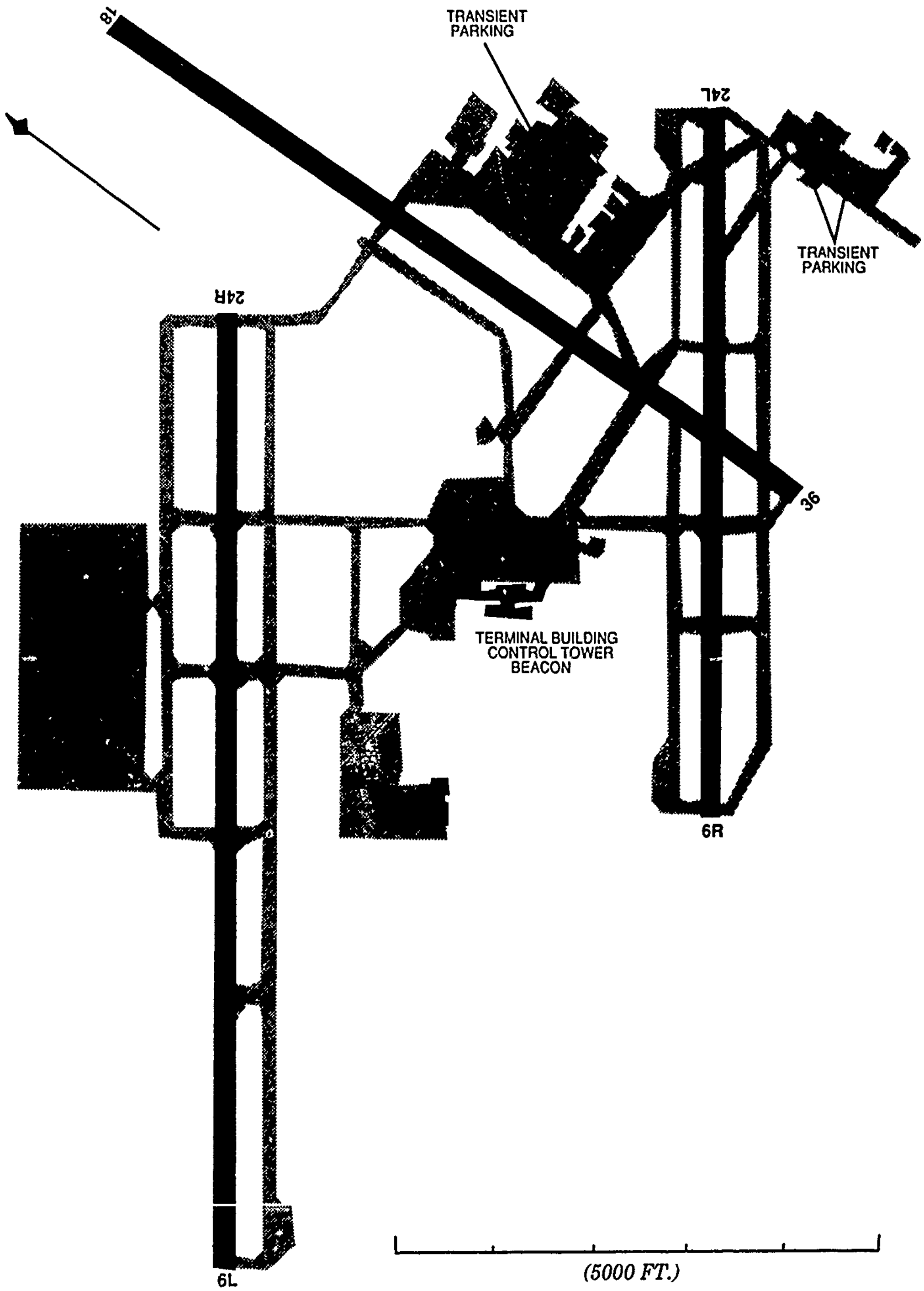
Dallas-Fort Worth (DFW)

Planned 2,000 foot extensions to Runways 17R and 18L will provide an overall length of 13,400 feet for each. Each extension is estimated to cost $24 million. The tentative date of completion of the extensions is 1992. Also planned are two more parallel runways, 16L/34R and 16R/34L. The east runway, Runway 16L/34R, encompasses a two-stage action. Initially, a 6,000 foot runway will be constructed for ultimate phased extension to 8,500 feet. It will be located 5,000 feet east of and parallel to 17L/35R. The estimated cost is $100 million. It is anticipated that the 6,000 foot runway will be operational by 1993. Construction on the west runway, Runway 16R/34L, should begin in 1993 and is expected to be completed in 1997. The estimated cost is $95 million. It will be located west of Runway 18R/36L. These runways could potentially permit triple or quadruple IFR arrival operations (78 and 104 hourly IFR arrivals, respectively) if the multiple appoach concepts are approved.



Dayton (DAY)

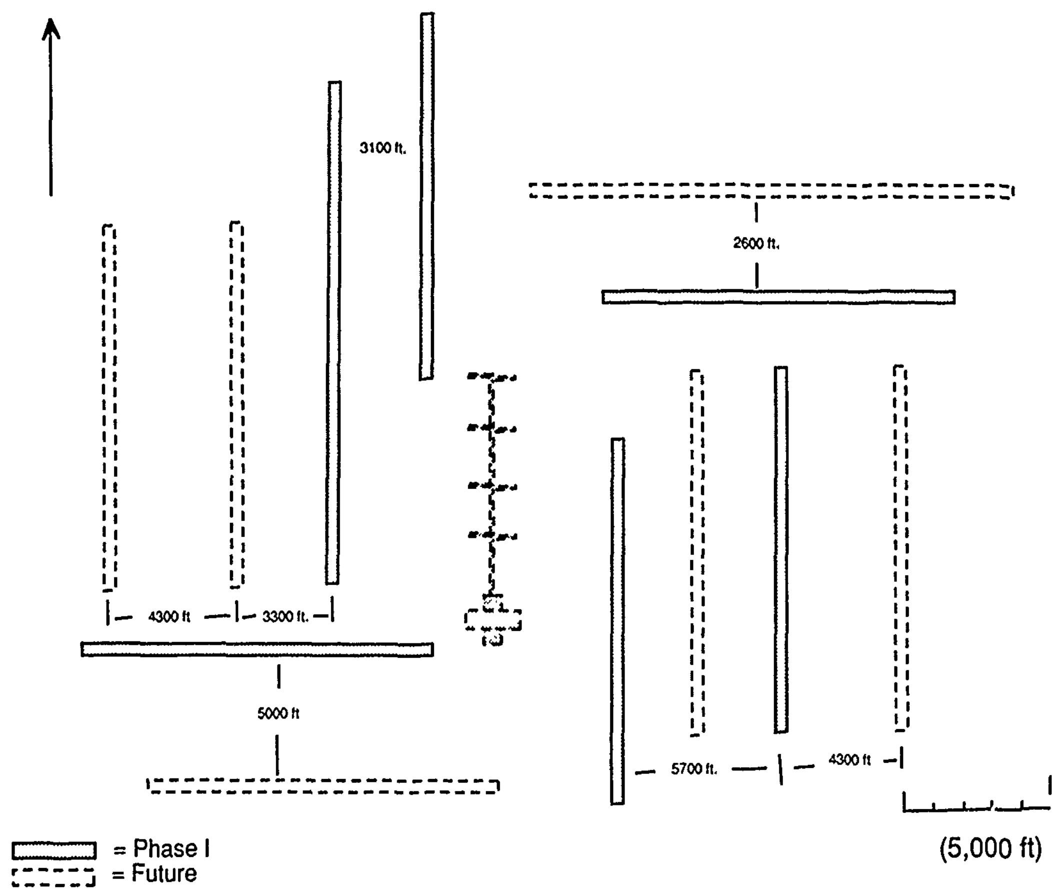
The 1,400 foot extension of Runway 6L/24R from 9,500 to 10,900 feet was completed in late 1989. The cost of construction was $10.8 million. A Master Plan shows a later extension of Runway 6L/24R to 11,000 feet to accommodate overseas departures.



JAMES M. COX
DAYTON INTERNATIONAL AIRPORT

New Denver (DVX)

The initial phase of the new Denver airport will consist of six runways. The current plan involves four north-south parallels and two east-west parallels. Runway 17C/35C will initially be the farthest west of the four north-south parallels. It will be located 3,100 feet west of Runway 17L/35R and 10,700 feet west of Runway 18R/36L. Runway 18R/36L and Runway 18L/36R will be separated by 5,700 feet. East-west parallels, Runways 8L/26R and 9R/27L, will have centerlines 13,500 feet apart. Runway 8L/26R is south of Runways 17C/35C and 17L/35R. Runway 9R/27L is north of Runways 18R/36L and 18L/36R. Construction began 28 September 1989. The total estimated cost of construction is $2.5 billion. The new airport is expected to be operational in October 1993. The airport could potentially operate independent triple or quadruple IFR approaches, if approved (quadruple approaches under this configuration would require one dependent pair or use of the PRM). This could increase Denver hourly IFR arrival capacity from 52 to 78 (triples) or more (quadruples) per hour. A second future phase proposes the construction of six more runways.

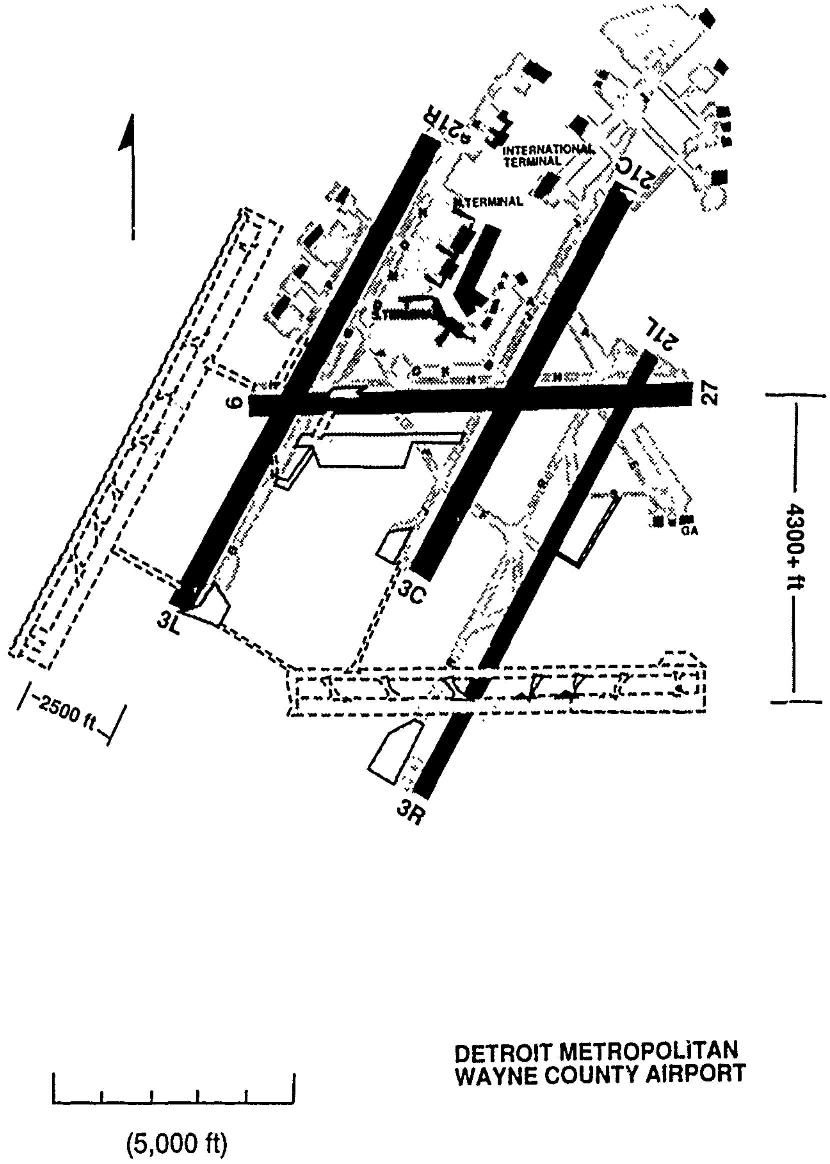


NEW DENVER AIRPORT

Revised 7/06/90

Detroit (DTW)

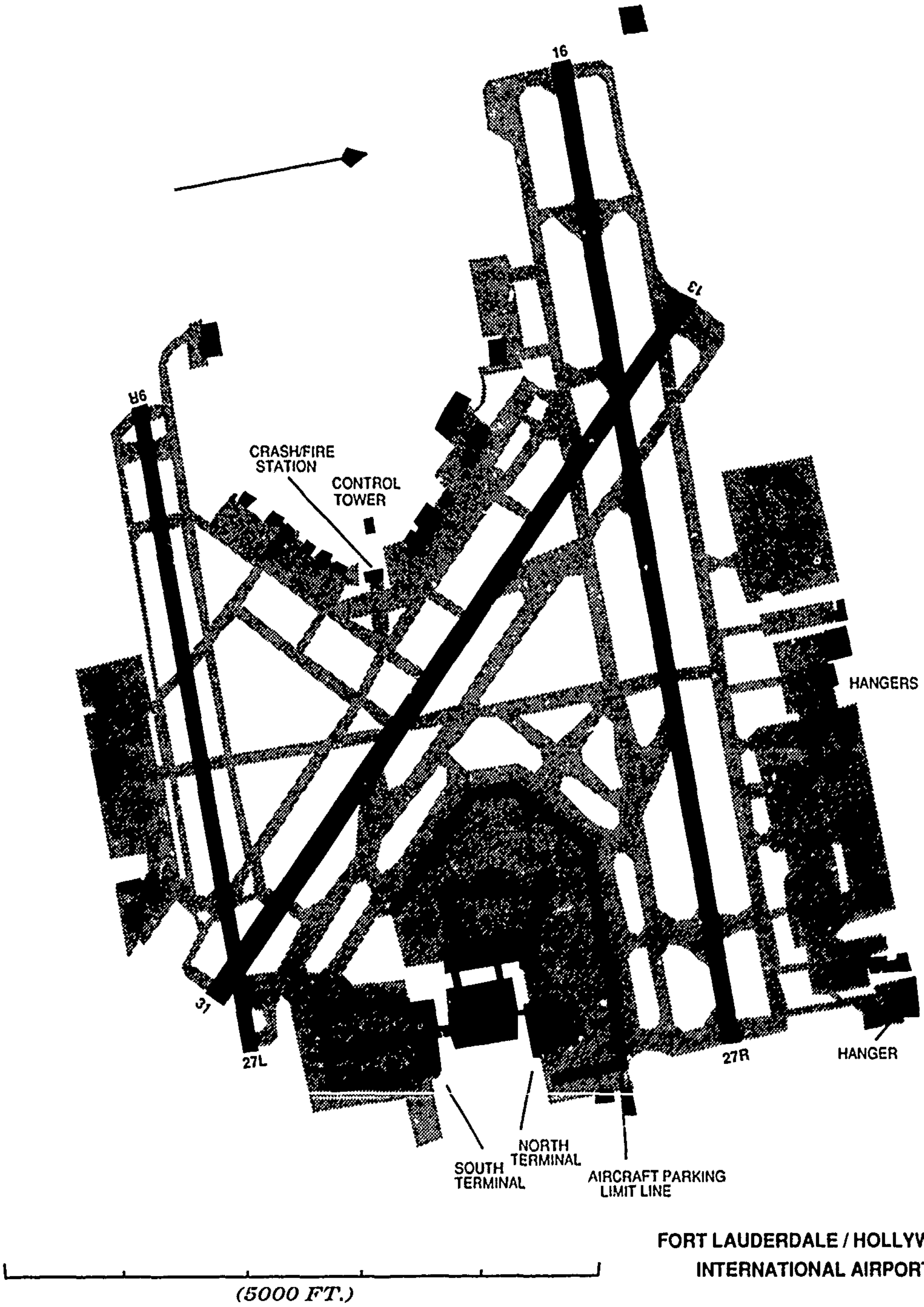
Runway 9R/27L is planned, located more than 4,300 feet from and parallel to existing Runway 9/27. The estimated cost is $69.1 million. This new runway will allow DTW to run independent parallel IFR approaches in an east-west configuration, thus matching their current north-south IFR arrival capabilities. Construction is estimated to begin in 1990 and should be completed in 1991. A fourth north-south parallel, Runway 4/22, 2,500 feet west of Runway 3L/21R, is also planned. Construction is expected to begin in 1994 and should be completed in 1995. The estimated cost of construction is $58.2 million. This runway could potentially permit triple IFR arrivals with one dependent and one independent pairing. If approved, hourly IFR arrival capacity could increase from 52 to 63. An environmental assessment was submitted in September 1989 and a record of decision was issued in March 1990 for all three projects.



DETROIT METROPOLITAN
WAYNE COUNTY AIRPORT

Fort Lauderdale (FLL)

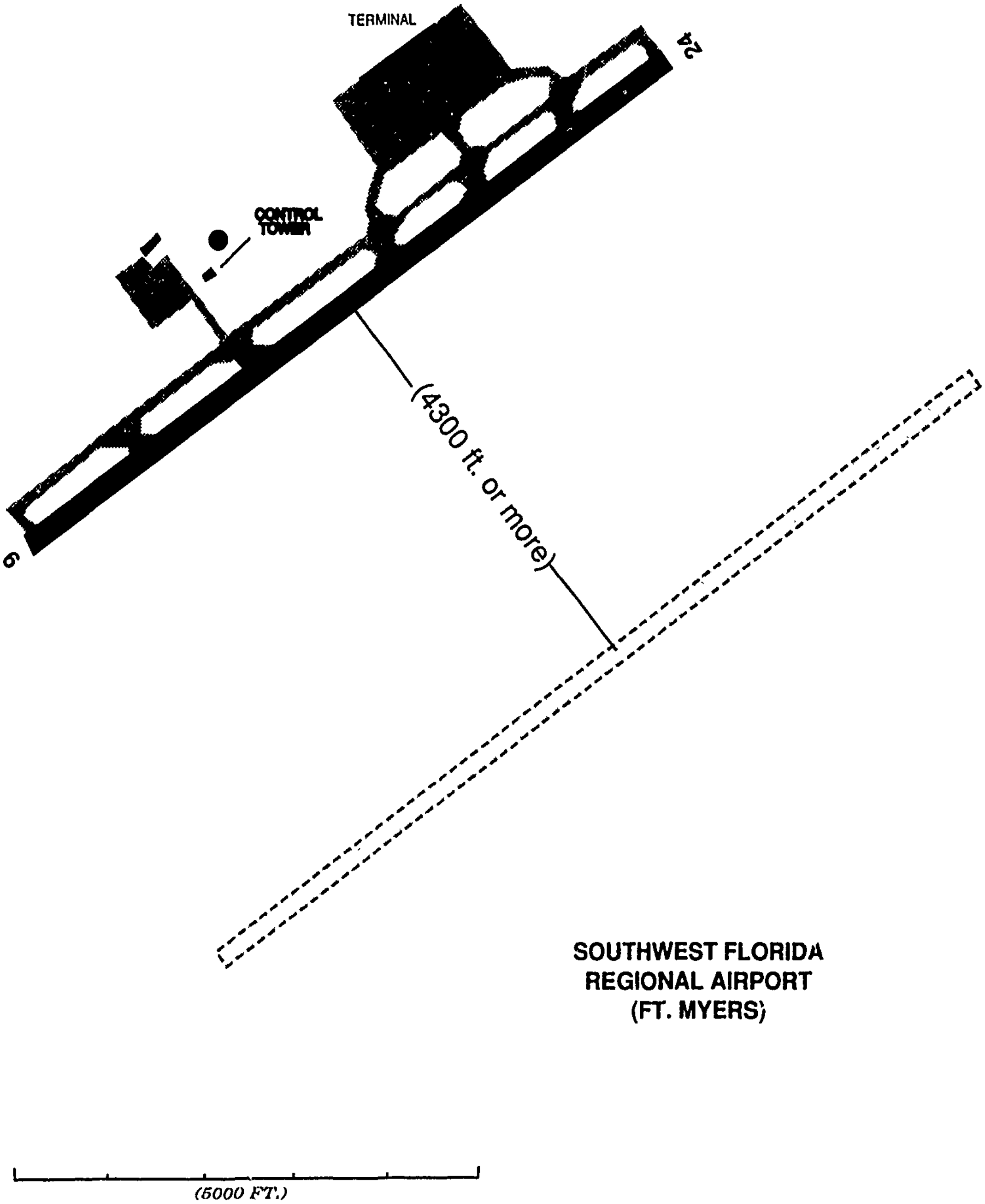
Runway 9L/27R was strengthened and extended 982 feet to a length of 9,000 feet. It became operational in September 1989 at a cost of $3 million. An extension of the short parallel Runway 9R/27L to 6,000 feet by 150 feet wide is planned to provide the airport with a second parallel air carrier runway. Construction is expected to begin in 1994. The estimated cost of construction is $26 million and the anticipated operational date is 1995. Extension of this short parallel runway would permit IFR arrival capacity to increase from 26 to 52 per hour in an independent parallel operation.



FORT LAUDERDALE / HOLLYWOOD INTERNATIONAL AIRPORT

Fort Myers (RSW)

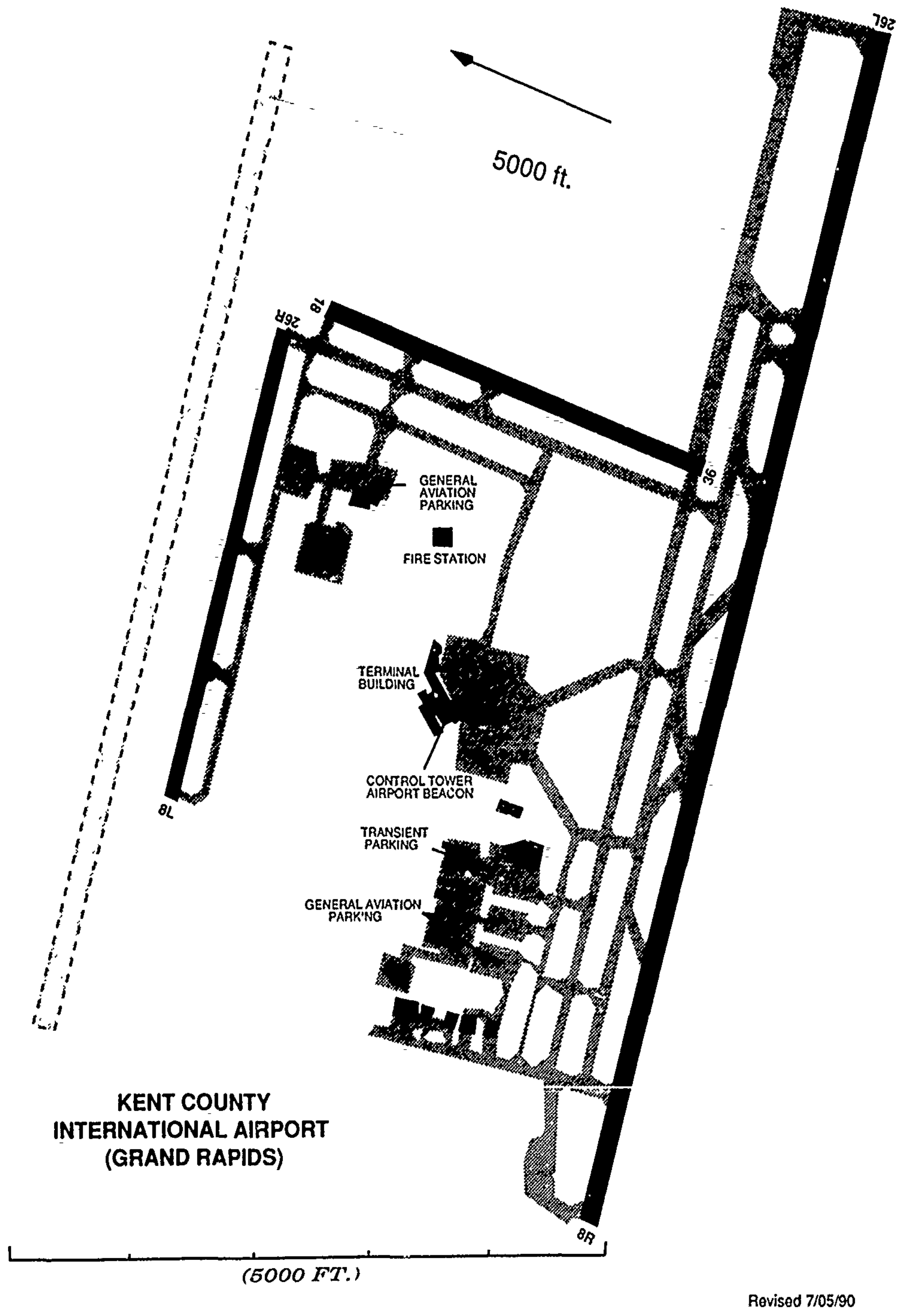
Planning has begun for a 9,000-10,000 foot new parallel runway, Runway 6R/24L, 4,300 feet or more from the existing air carrier runway. Construction is expected to begin in 1992. It is estimated to be operational by 1994 at a cost of $47 million. This would provide independent parallel operations with potential to increase IFR hourly arrival capacity from 26 to 52. An environmental assessment is underway for an extension of runway 6/24 from 8,400 feet to 10,600 feet. Construction is expected to begin in 1991. The estimated cost of the extension is $10 million and the estimated operational date is 1992.



Revised 7/26/90

Grand Rapids (GRR)

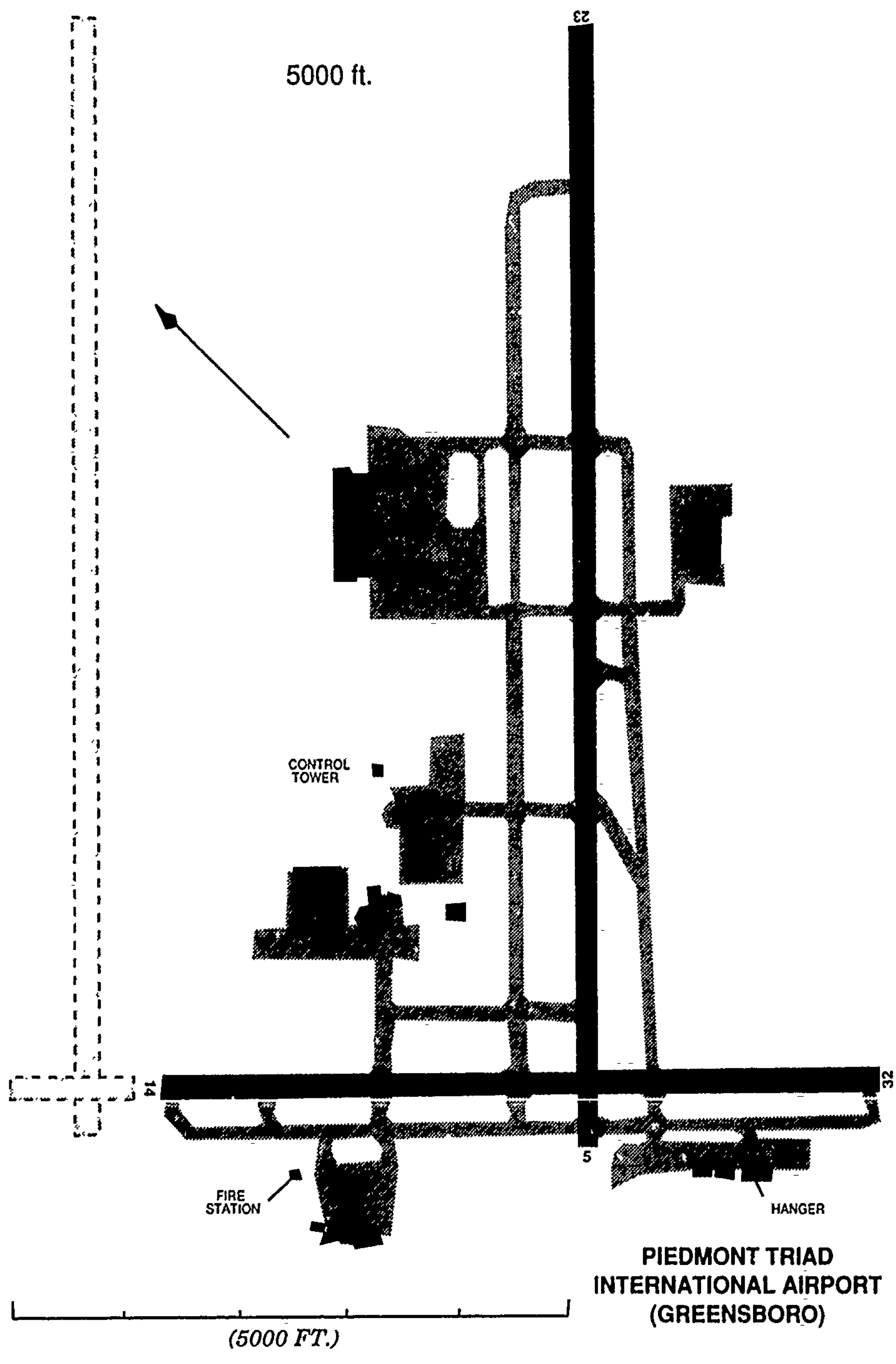
A new 7,000 foot parallel runway, Runway 8L/26R, 5,000 feet from Runway 8R/26L, is being considered. The current 3,918 foot Runway 8L/26R would become a taxiway. An environmental assessment is underway and is expected to be submitted in August 1990. Construction is scheduled to start in 1992 and should be completed by late 1993. The estimated cost of construction is $25 million. This runway will potentially double hourly IFR arrival capacity from 26 to 52.



Revised 7/05/90

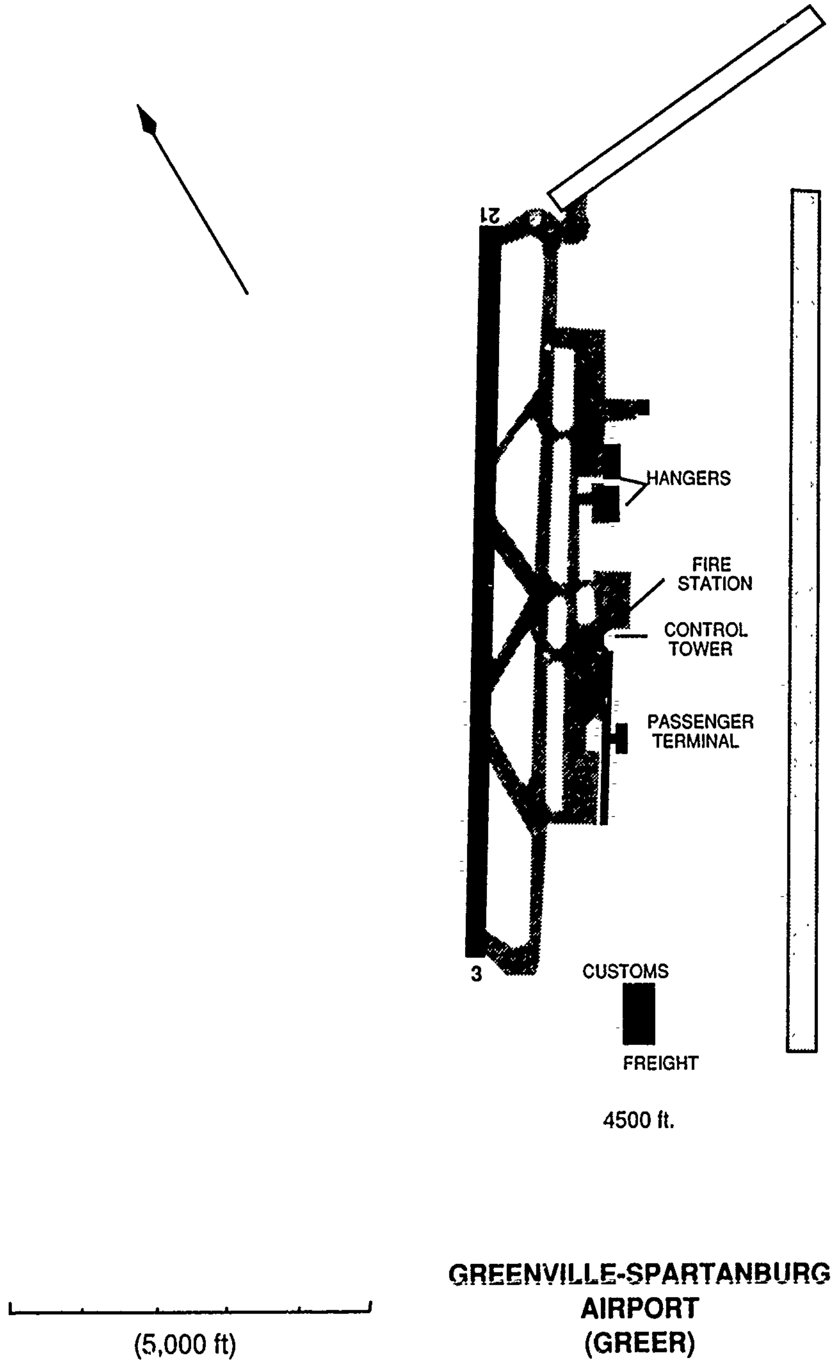
Greensboro (GSO)

An airport layout plan showing a new parallel Runway 5/23, 5,000 feet northwest of the existing Runway 5/23, and a 1,200 foot extension to Runway 14/32, is under preliminary review and is expected to be approved in July 1990. The new runway would permit independent parallel operations, potentially doubling hourly IFR arrival capacity from 26 to 52. Construction on the extension to Runway 14/32 is expected to begin in 1995 and should be completed in 1998 at a cost of $14 million. The 7,000 foot long parallel runway is estimated to cost $20 million. It is planned to be completed in 2010.



Greer Greenville-Spartanburg (GSP)

A new parallel runway, Runway 3R/21L, is anticipated in the late 1990s. Presently, its planned length is 5,900 feet with a 4,500 foot separation from Runway 3/21. This would potentially double hourly IFR arrival capacity from 26 to 52.

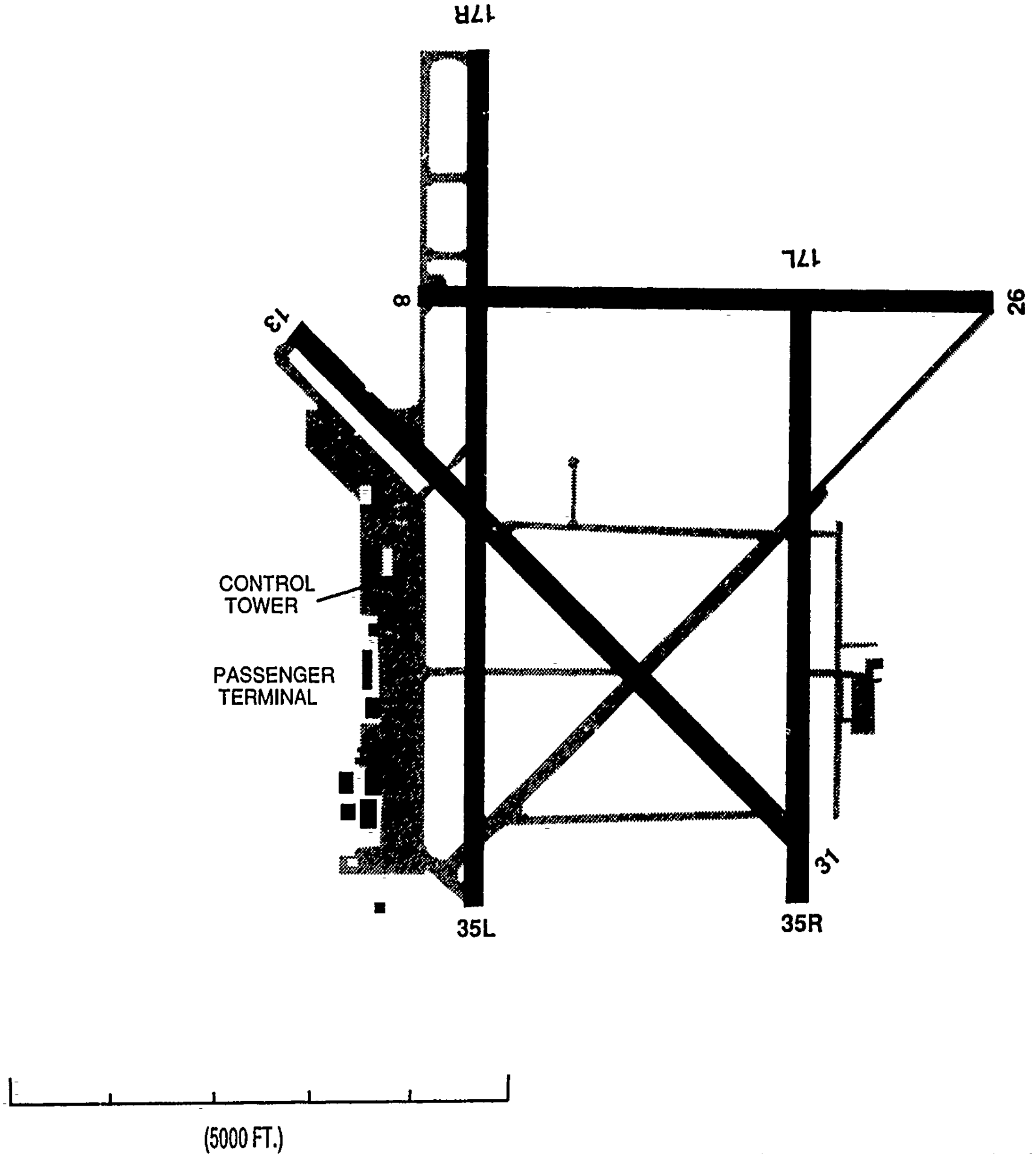


GREENVILLE-SPARTANBURG
AIRPORT
(GREER)

Revised 7/05/90

Harlingen (HRL)

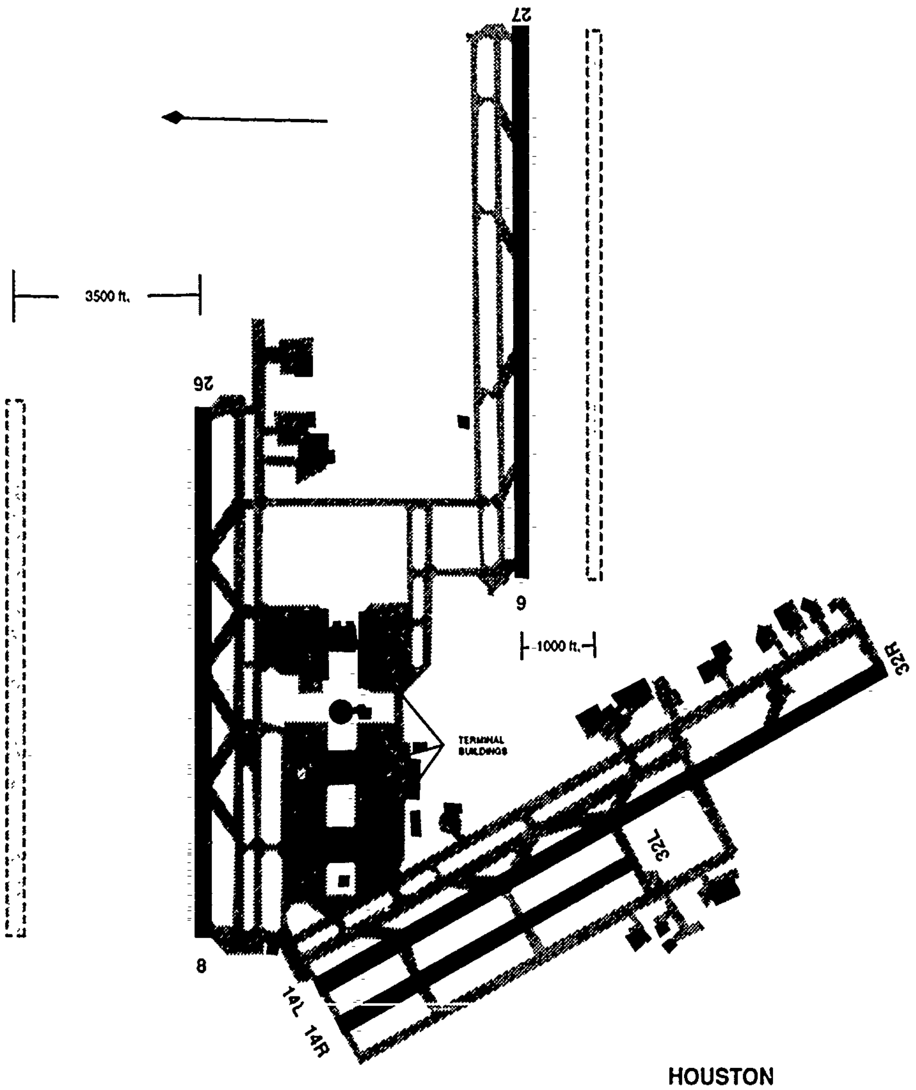
An approved airport layout is anticipated in late 1990, which will include an extension to Runway 13/31 and a new parallel GA runway, Runway 13L/31R. The extension to Runway 13/31 will bring the runway length to 9,500 feet at an estimated cost of $6.7 million. A noise study and environmental assessment are expected in 1992. Construction is anticipated to begin in 1994 and should be completed in 1995. The new GA Runway 13L/31R will be 5,000 feet long. Construction is expected to begin in 1994. Runway 13L/31R should also be operational in 1995 at a cost of $5 million.



RIO GRANDE VALLEY INTERNATIONAL AIRPORT (HARLINGEN)

Houston (IAH)

An $8 million, 2,000 foot extension to Runway 14R/32L is planned to be operational in 1997. Construction is expected to begin in 1996. A new runway, Runway 8L/26R, is planned to be completed sometime in 1999. Construction should begin in 1997 and is estimated to cost $44 million. This runway will be parallel to and north of existing Runway 8/26. The spacing between these two runways will be 3,500 feet. Runway 8L/26R, in conjunction with Runways 9/27 and 8/26, has the potential for allowing triple IFR approaches, if approved, which could increase hourly IFR arrival capacity from 52 to 78. Another new runway, parallel to and south of Runway 9/27 is also planned. Construction is expected to begin in 1999, and be completed in 2002, also at a cost of $44 million. This runway will be separated from Runway 9/27 by only 1,000 feet, which, while not supporting additional IFR arrival capacity, would increase available departure capacity.



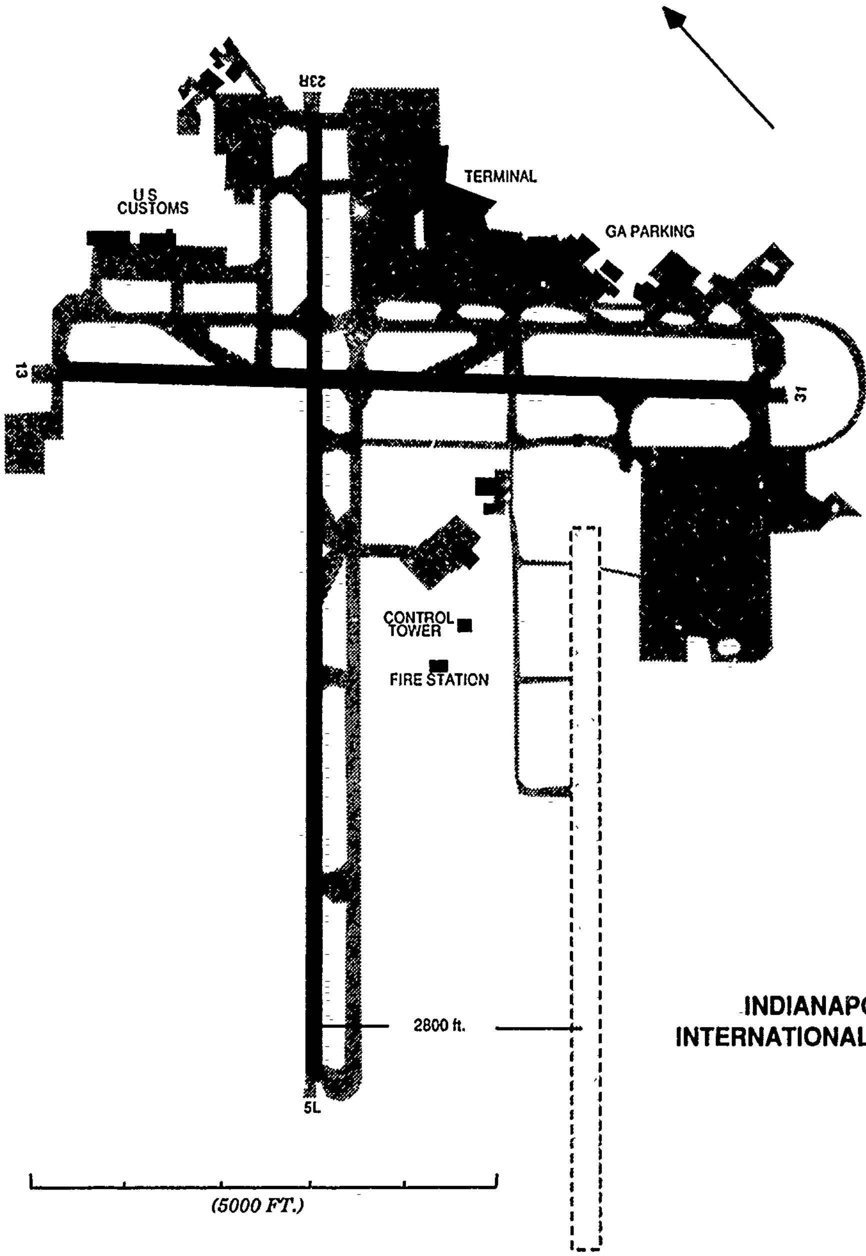
HOUSTON
INTERCONTINENTAL AIRPORT

(5,000 ft)

Revised 7/05/90

Indianapolis (IND)

A new runway, Runway 5R/23L, parallel to and 2,800 feet away from the existing Runway 5L/23R, is scheduled to become operational in 1990. The runway dimensions are 10,000 feet by 150 feet. A CAT I ILS is scheduled for late 1990. This will permit dependent parallel operations, increasing hourly IFR arrival capacity from 26 to 36. Total development costs are estimated to be $44.6 million. Construction is scheduled to begin in 1993 for a replacement for Runway 5L/23R. The estimated cost is $42 million and the estimated operational date is 1995.

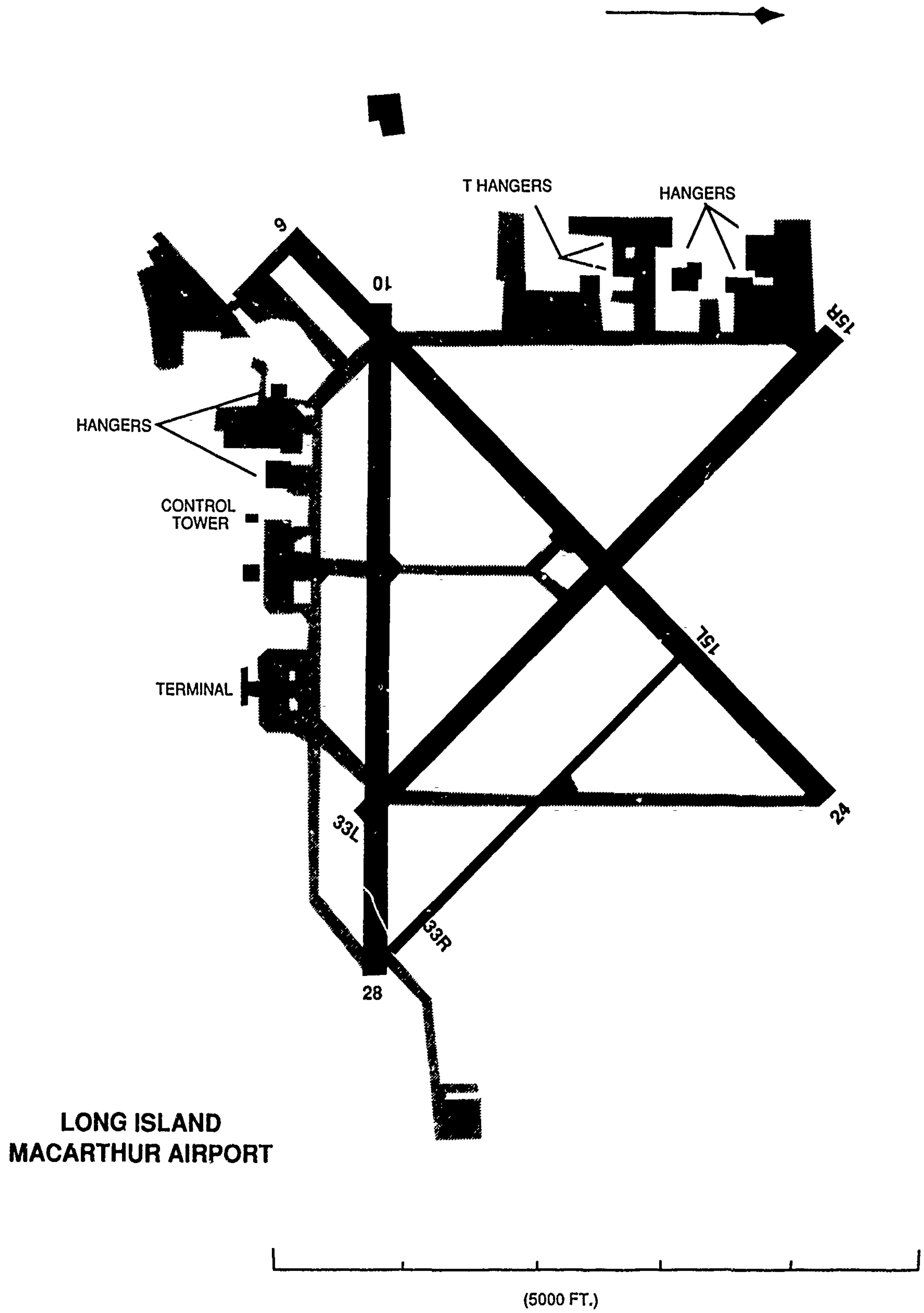


INDIANAPOLIS INTERNATIONAL AIRPORT

Revised 7/05/90

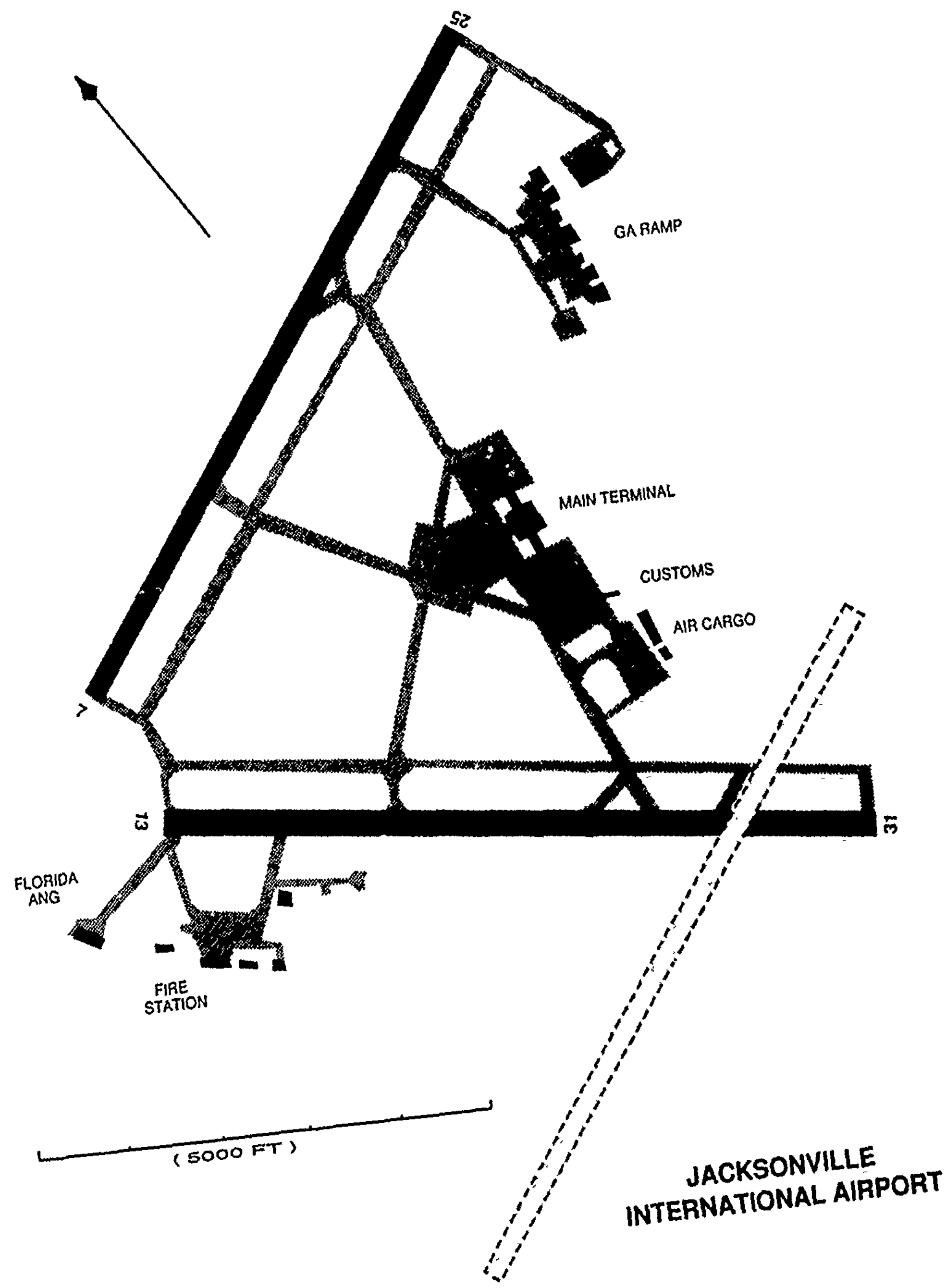
Islip (ISP)

A 1,000 foot extension to Runway 6/24 is planned.



Jacksonville (JAX)

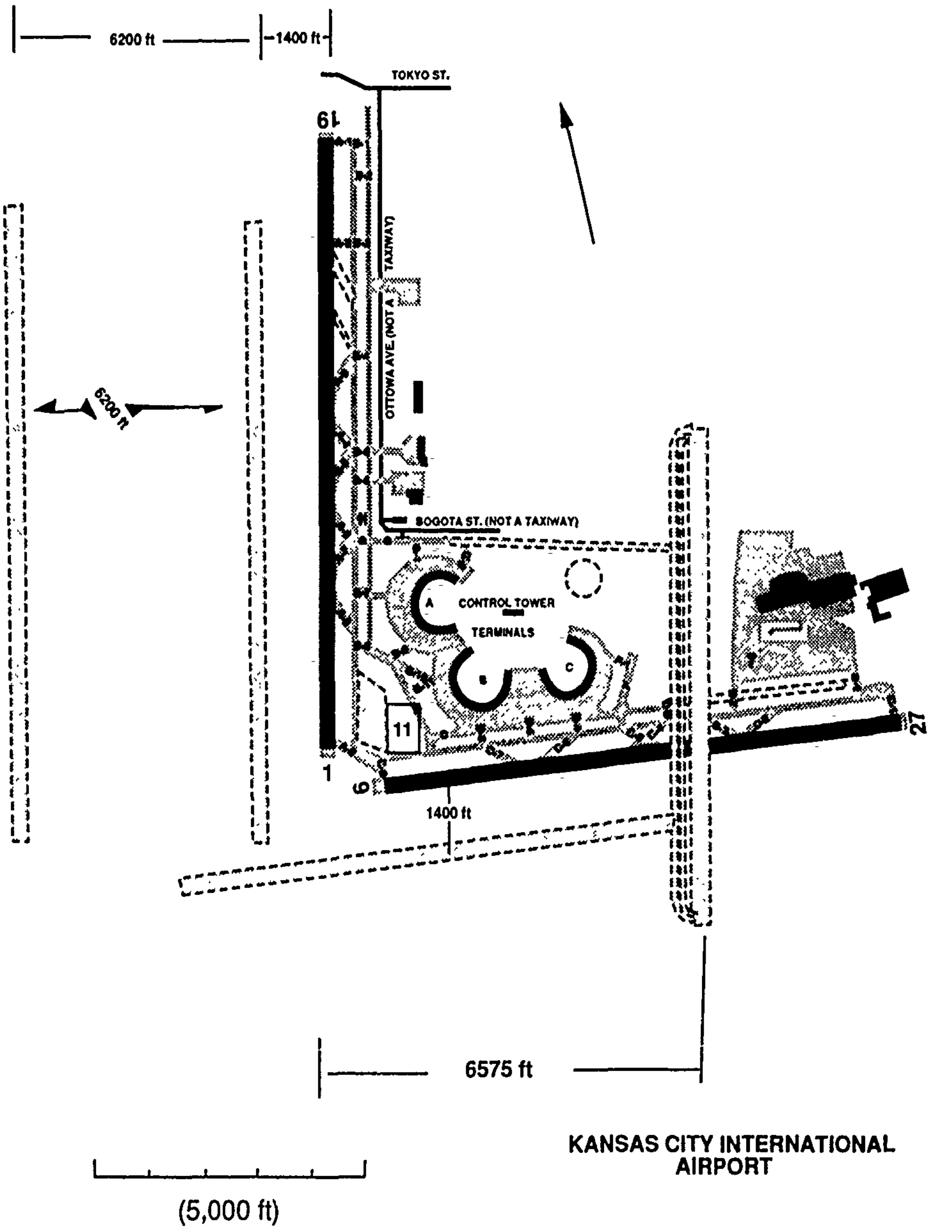
Runway 7R/25L is planned. It will be 6,500 feet south of the existing Runway 7/25, permitting independent parallel IFR operations and potentially doubling Jacksonville's hourly IFR arrival capacity. Plans and specifications for the new runway will start in 1991. The estimated cost of construction is $37 million.



Revised 7/06/90

Kansas City (MCI)

A new north-south parallel runway, Runway 1R/19L, is currently under construction. It will be located 6,575 feet east of existing Runway 1/19, permitting independent parallel IFR operations. Construction began in October 1989 and should be completed in 1992. The estimated cost of construction is $46.2 million. A new runway, Runway 9R/27L is proposed to be located 1,400 feet south of existing Runway 9/27. Runway 18L/36R is proposed to be constructed after 2000. This runway will be 1,400 feet away, parallel to and west of existing Runway 1/19, and 7,975 feet from Runway 1R/19L. Runway 18R/36L is proposed for the longer term. This runway would be located 6,200 feet west of Runway 18L/36R. The construction of this runway would allow triple IFR approaches, increasing average hourly IFR arrival capacity from 52 to 78.

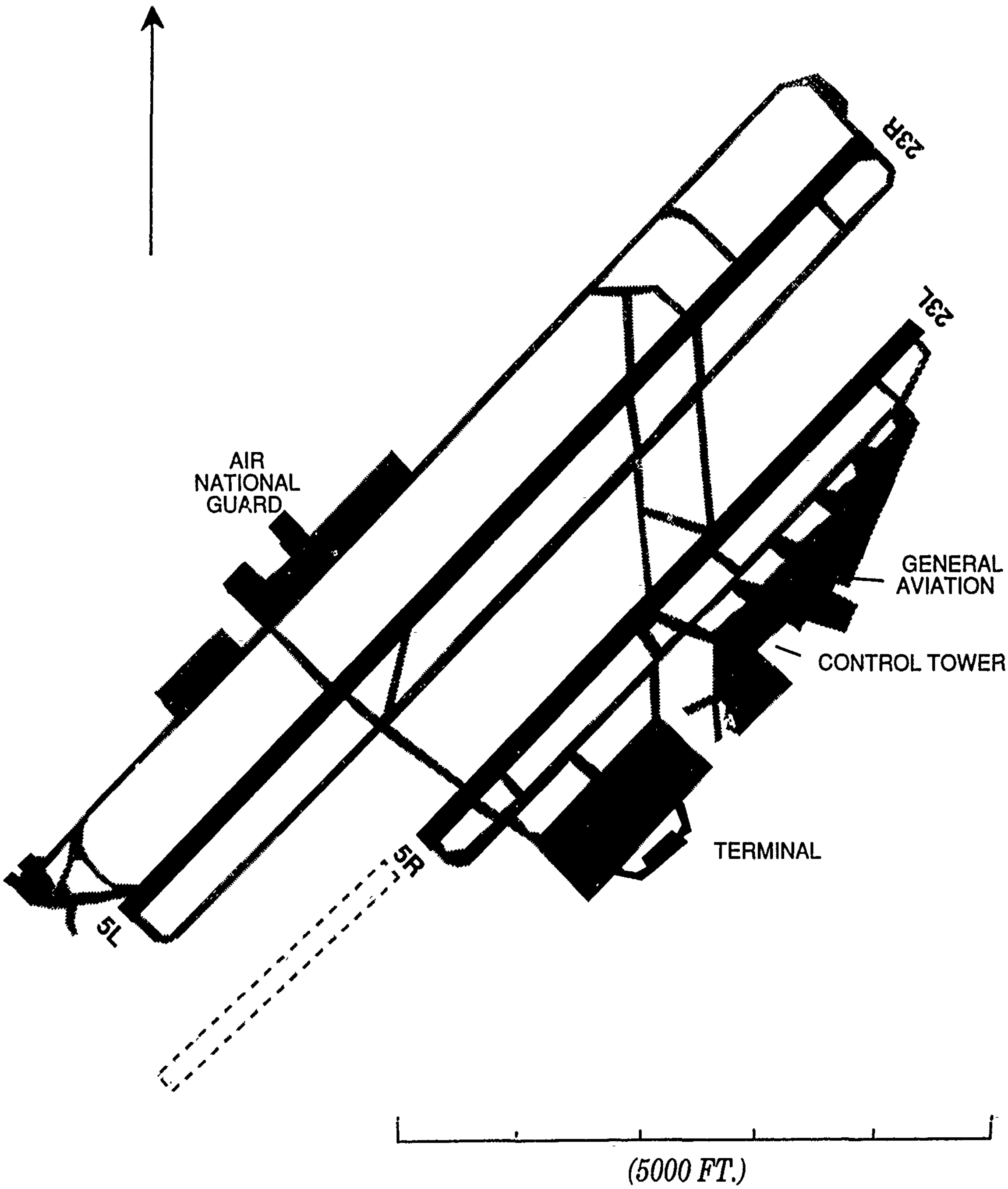


KANSAS CITY INTERNATIONAL AIRPORT

Revised 7/06/90

Knoxville (TYS)

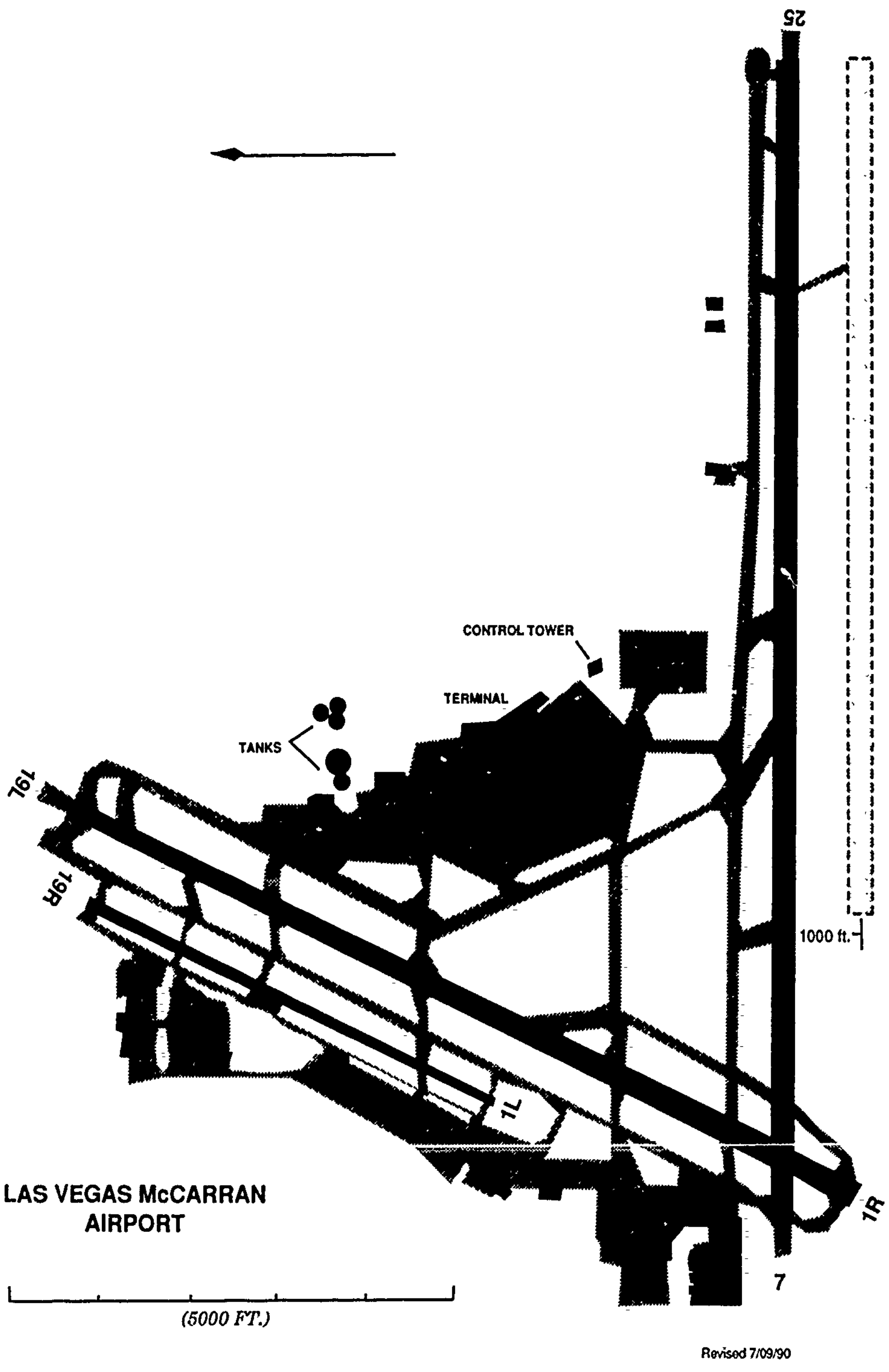
A 3,000 foot extension of Runway 5R/23L from 6,000 to 9,000 feet is under multi-year grant. Construction began in June 1989. The projected date of commissioning is 1992. The estimated cost of construction is $17.4 million.



MCGEE TYSON AIRPORT (KNOXVILLE)

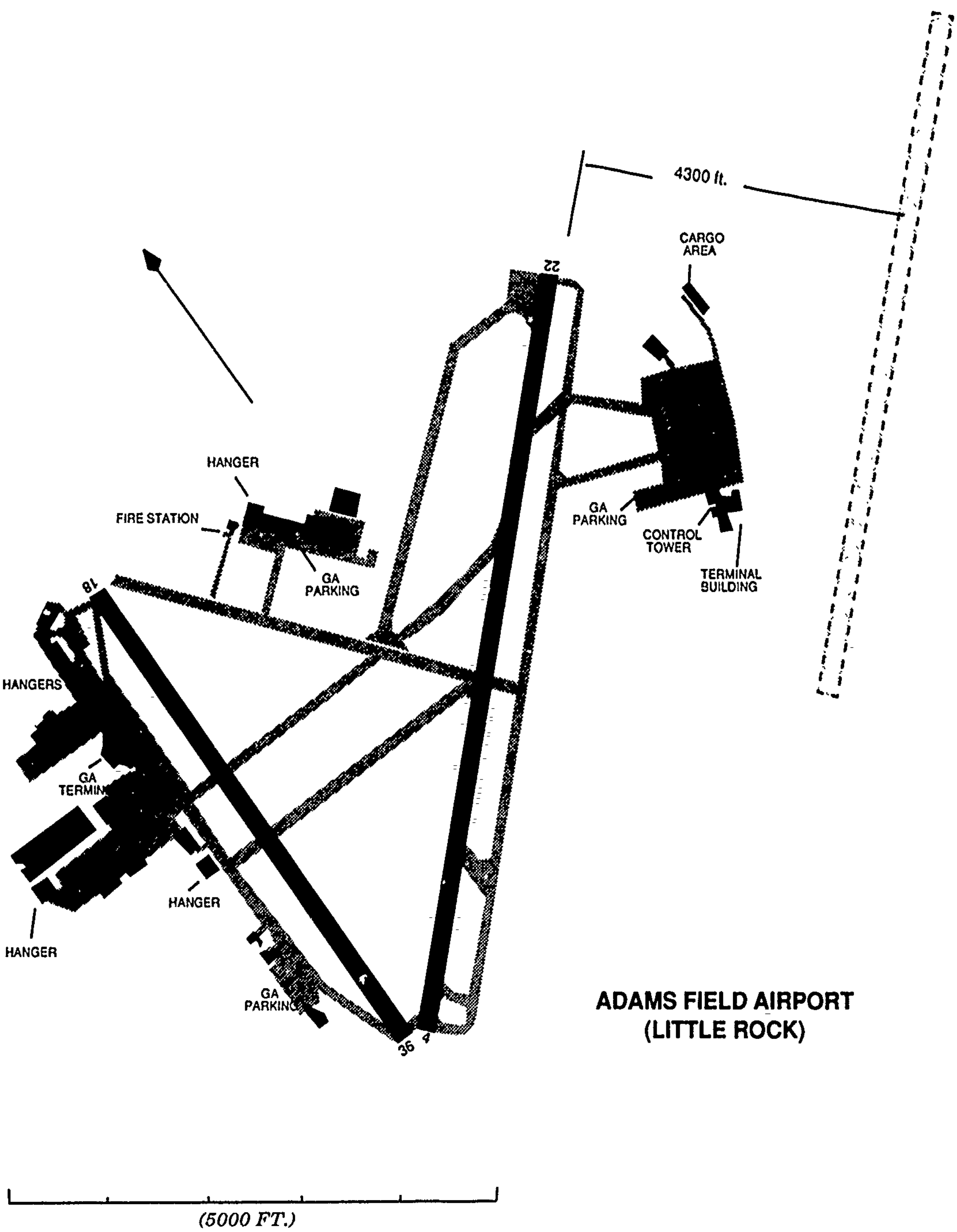
Las Vegas (LAS)

A new 8,900 foot runway, Runway 7R/25L will be constructed parallel to and 1,000 feet south of Runway 7/25. Construction is planned to begin in 1990. The runway is expected to be operational in 1991. While this will increase departure capacity, no increase in hourly IFR arrival capacity will be provided. The estimated cost for the new runway is $42 million.



Little Rock (LIT)

Parallel runway 4R/22L, separated from Runway 4/22 by 4,300 feet, is under construction and estimated to be op :rational in 1991. This should allow independent parallel IFR operations, increasing hourly IFR arrival capacity from 26 to 52.

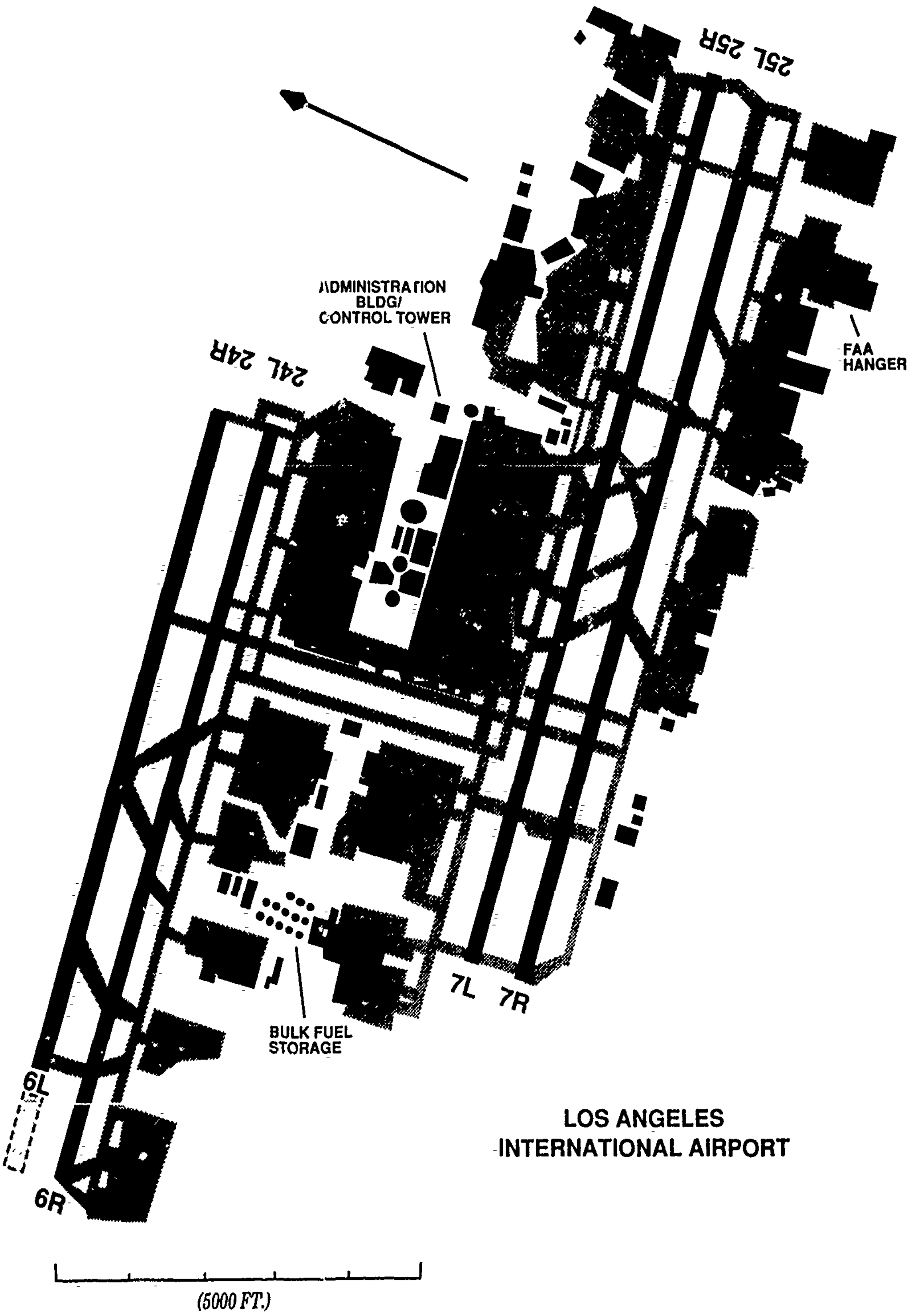


ADAMS FIELD AIRPORT (LITTLE ROCK)

Revised 7/06/90

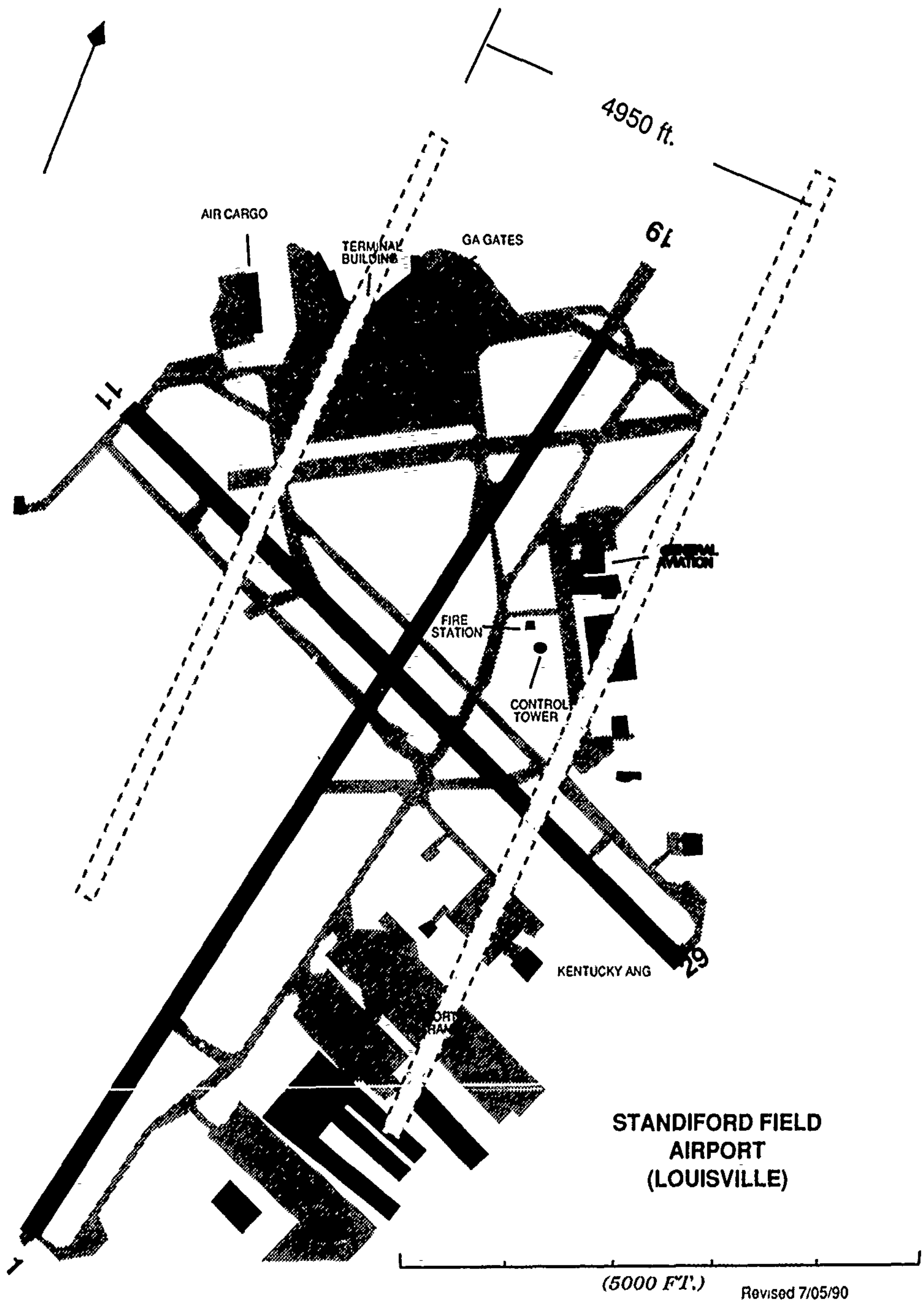
Los Angeles (LAX)

Runway 6L/24R is planned to be extended 1,360 feet to the west, to a length of 10,285 feet. This will improve the take-off capability of Runway 24R to equal that of Runway 24L. The estimated cost of construction is approximately $4 million.



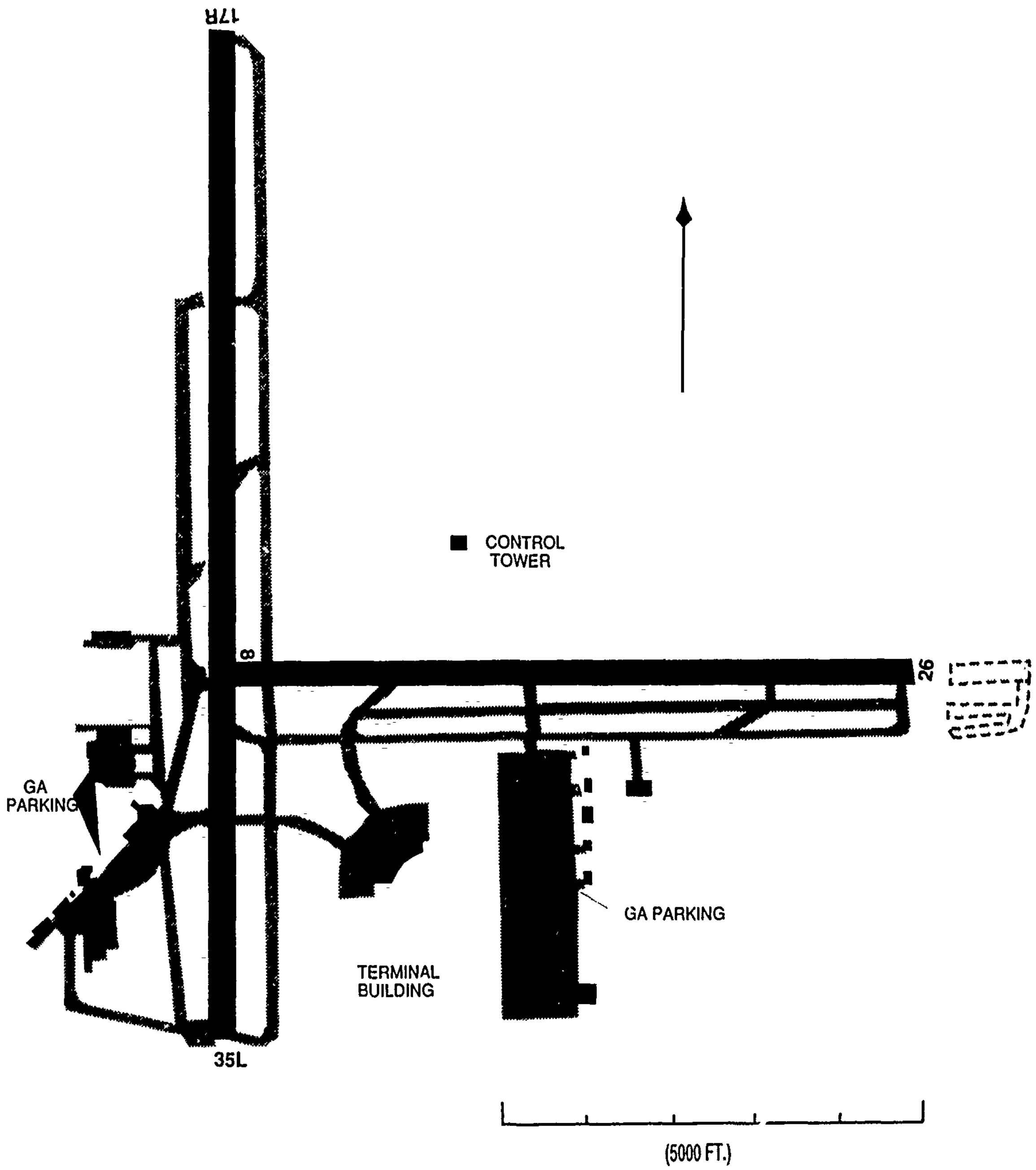
Louisville (SDF)

Plans have begun for two new parallel runways, 4,950 feet apart. They will be numbered 17R/35L and 17L/35R, and will be 10,000 and 7,800 feet long, respectively. They will replace Runway 1/19 which will be closed. The estimated cost of construction is $250 million. Construction is scheduled to begin in 1991. The east runway is expected to be operational in 1992. The west runway is expected to be operational in 1995, permitting independent parallel IFR operations that would increase hourly IFR arrival capacity from 26 to 52.



Lubbock (LBB)

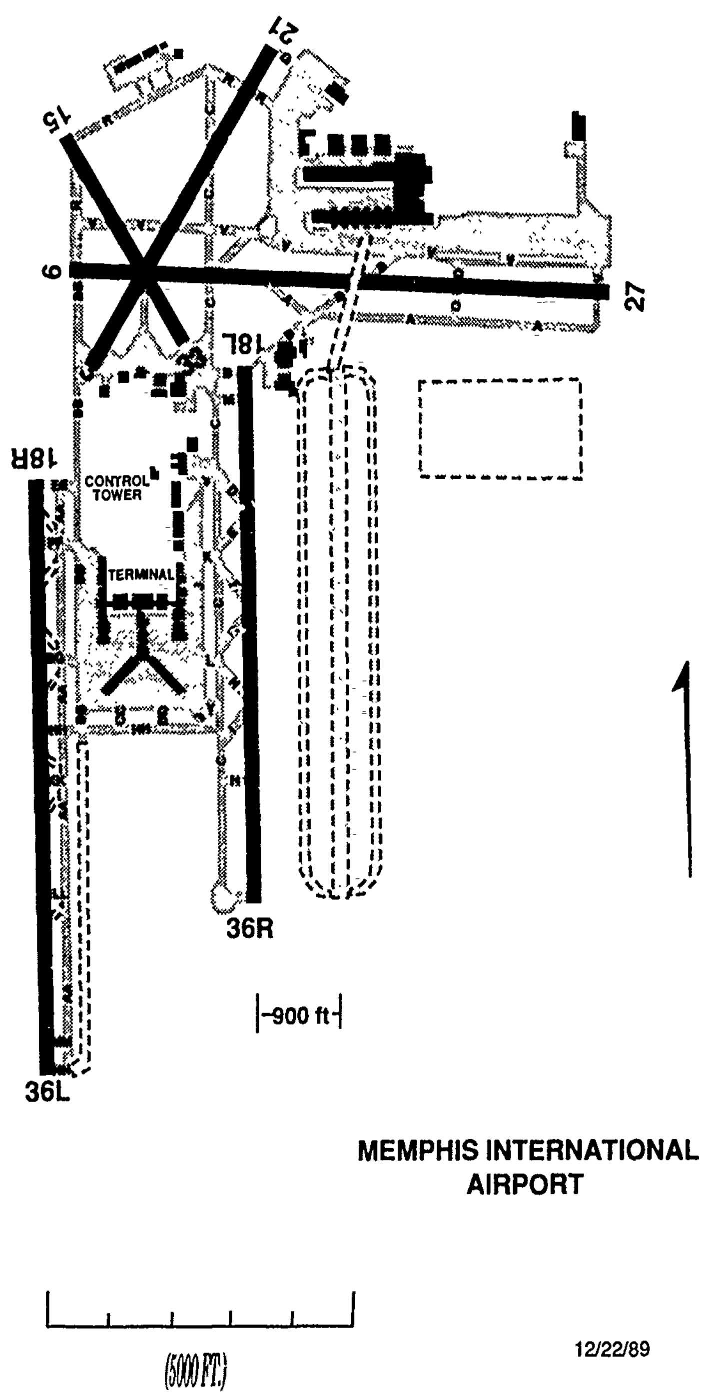
An extension to Runway 8/26 is planned. The expected start of construction is 1994. It is anticipated that the extension will become operational in 1995.



LUBBOCK INTERNATIONAL AIRPORT

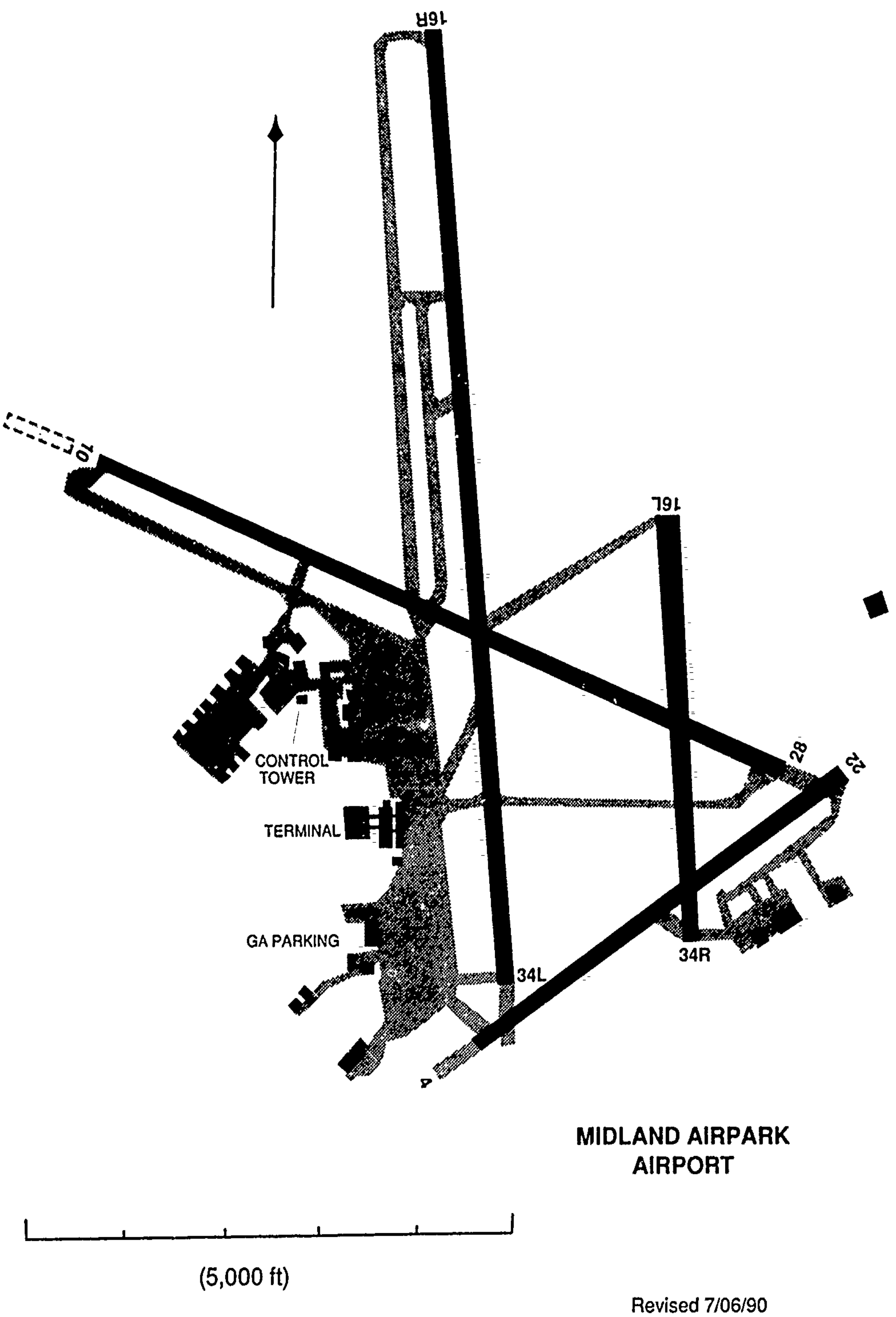
Memphis (MEM)

A new north-south runway, Runway 18L/36R, is planned, as noted in an ALP approved in June 1990. This new runway will be parallel to the existing pair of runways. It will be 8,990 feet by 150 feet, and will tentatively be located 900 feet east of Runway 18L/36R; this puts the runway 4,300 feet from Runway 18R/36L, thus allowing independent parallel approaches. This would double present hourly IFR arrival capacity. Construction is expected to start in 1991 and should be completed in 1994. The estimated cost is $105 million.



Midland (MAF)

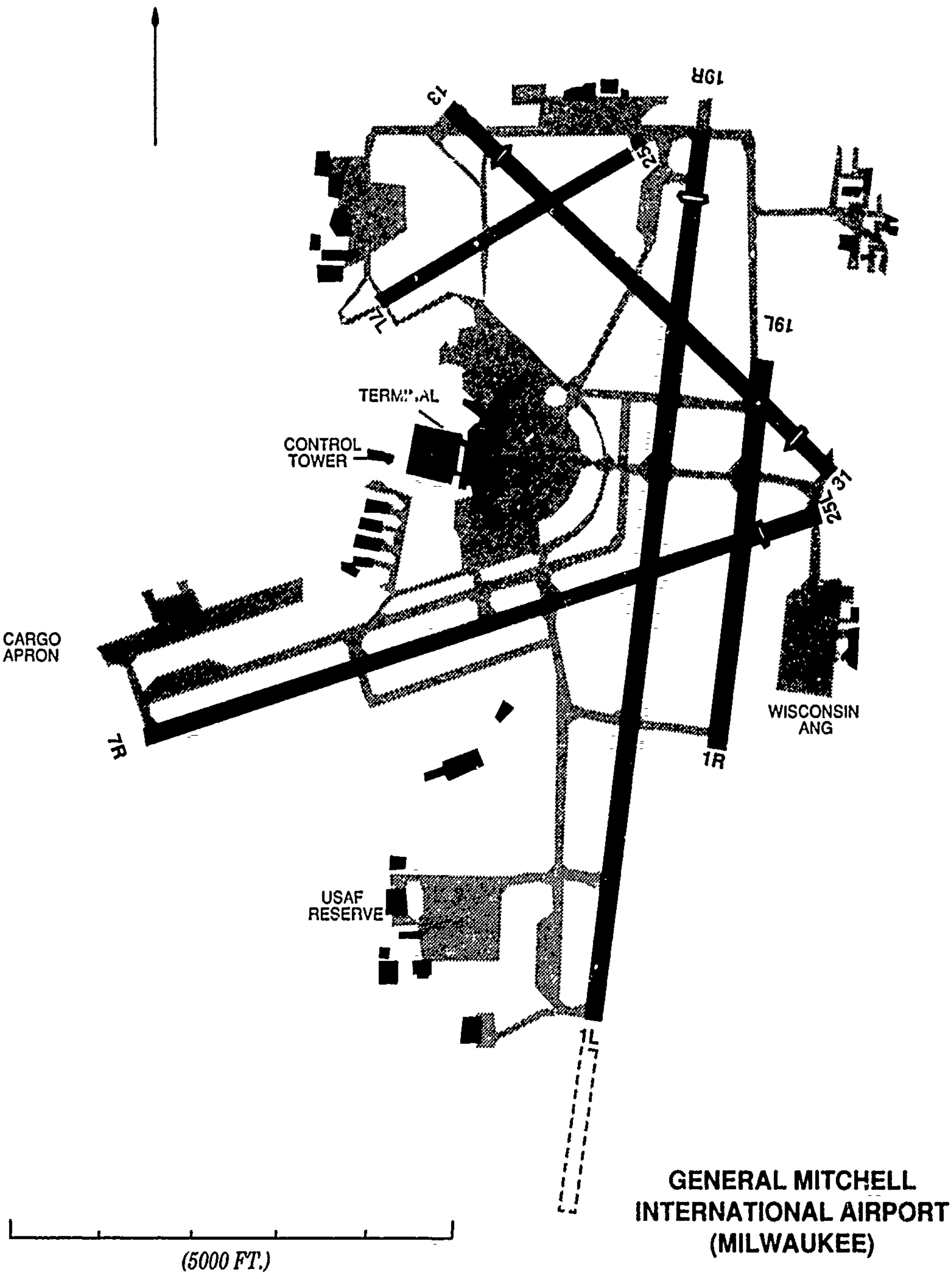
An extension to Runway 10/28 is planned. Construction is planned to begin in 1991. The extension is estimated to be commissioned in 1992. The estimated cost of construction is $5.8 million.



Revised 7/06/90

Milwaukee (MKE)

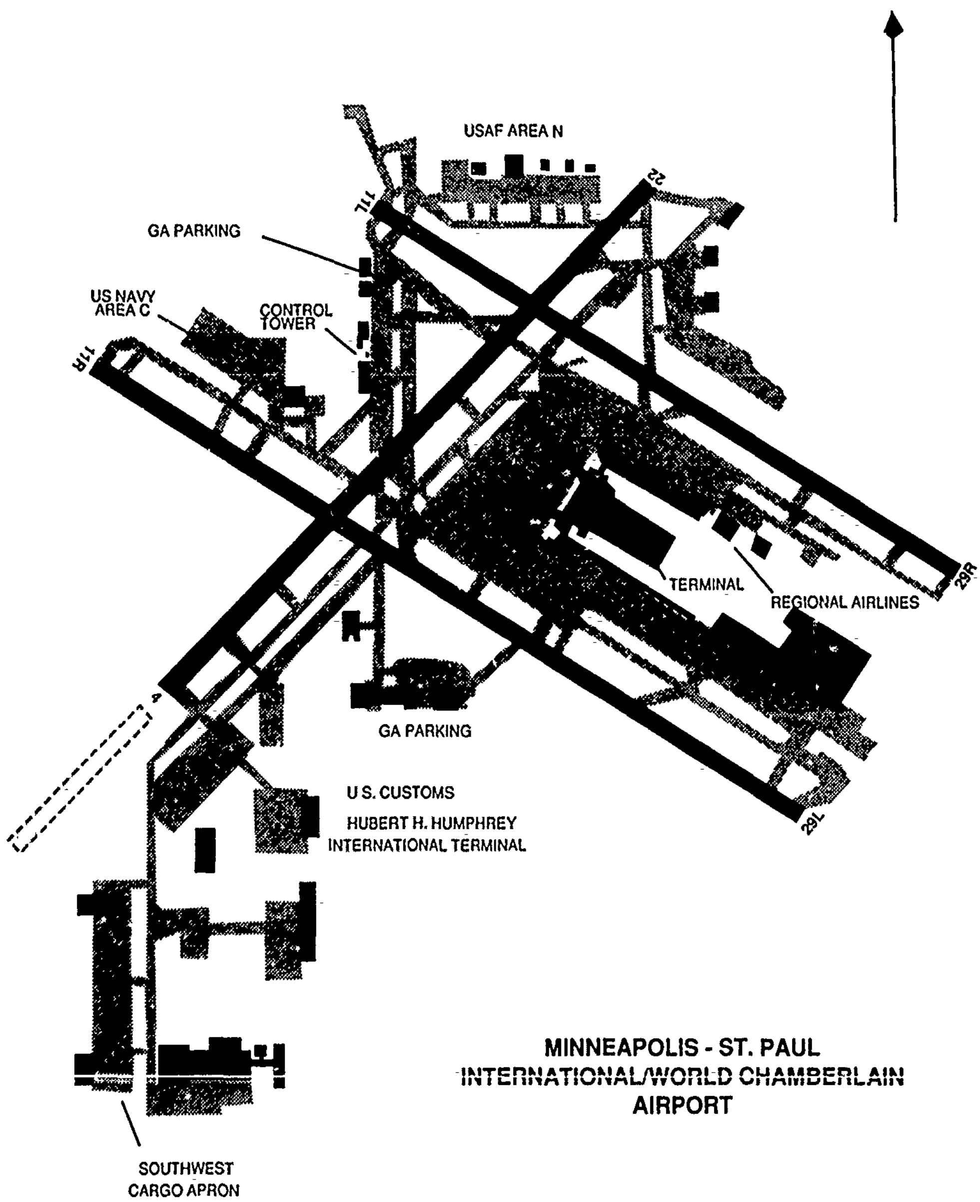
Runway 1L/19R is proposed to be extended 1,900 feet to the south for a total length to 11,600 feet. Construction is scheduled to begin in 1991 and should be completed in 1992 at a cost of $13 million.



Revised 7/06/90

Minneapolis (MSP)

An extension of Runway 4/22 2,750 feet to the southwest is proposed. This will bring the runway length to 11,000 feet. Construction is expected to begin in 1991 and the extension should be operational by the end of 1991. The estimated cost of construction is $11 million.



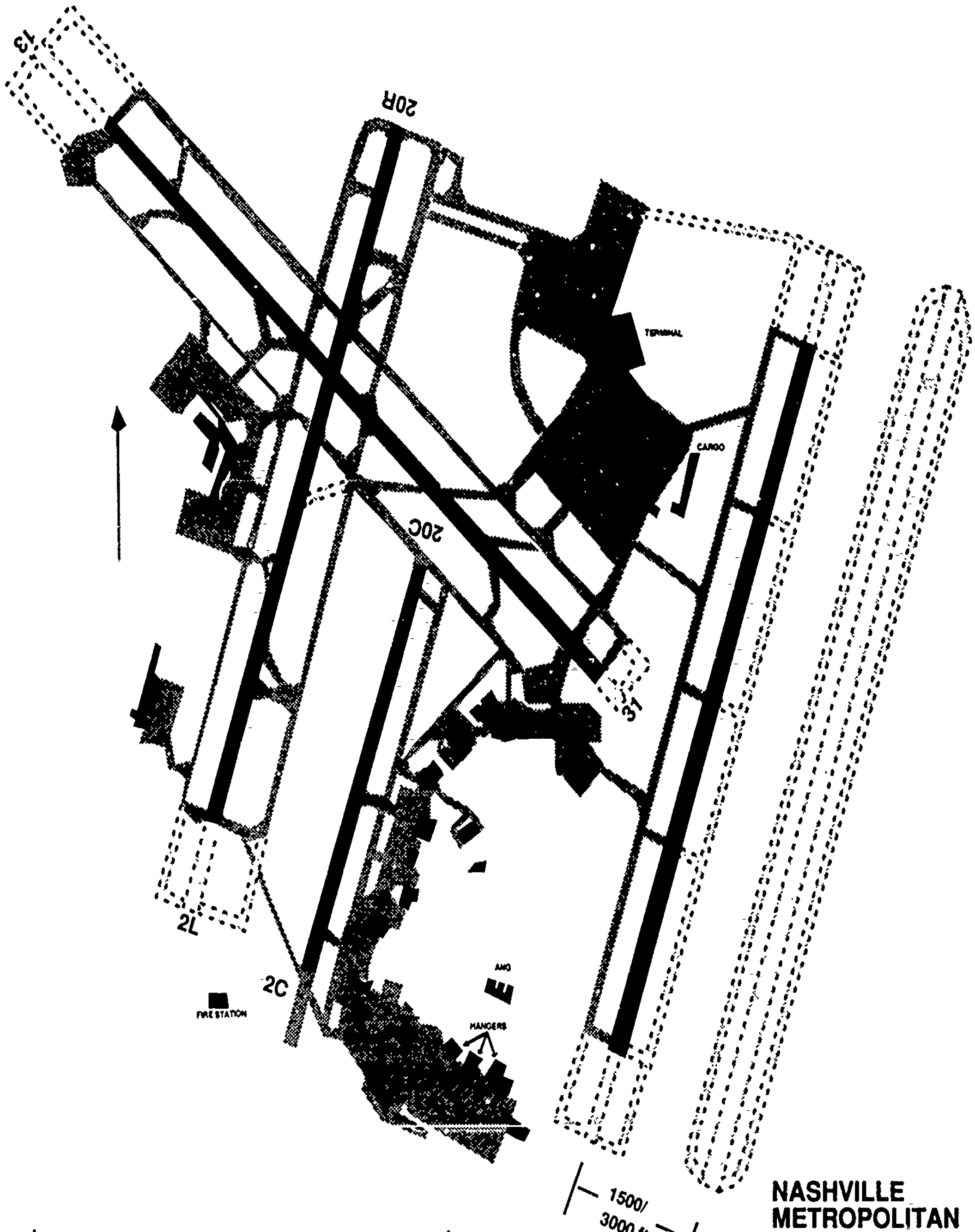
MINNEAPOLIS - ST. PAUL INTERNATIONAL/WORLD CHAMBERLAIN AIRPORT

(5000 FT.)

Revised 7/06/90

Nashville (BNA)

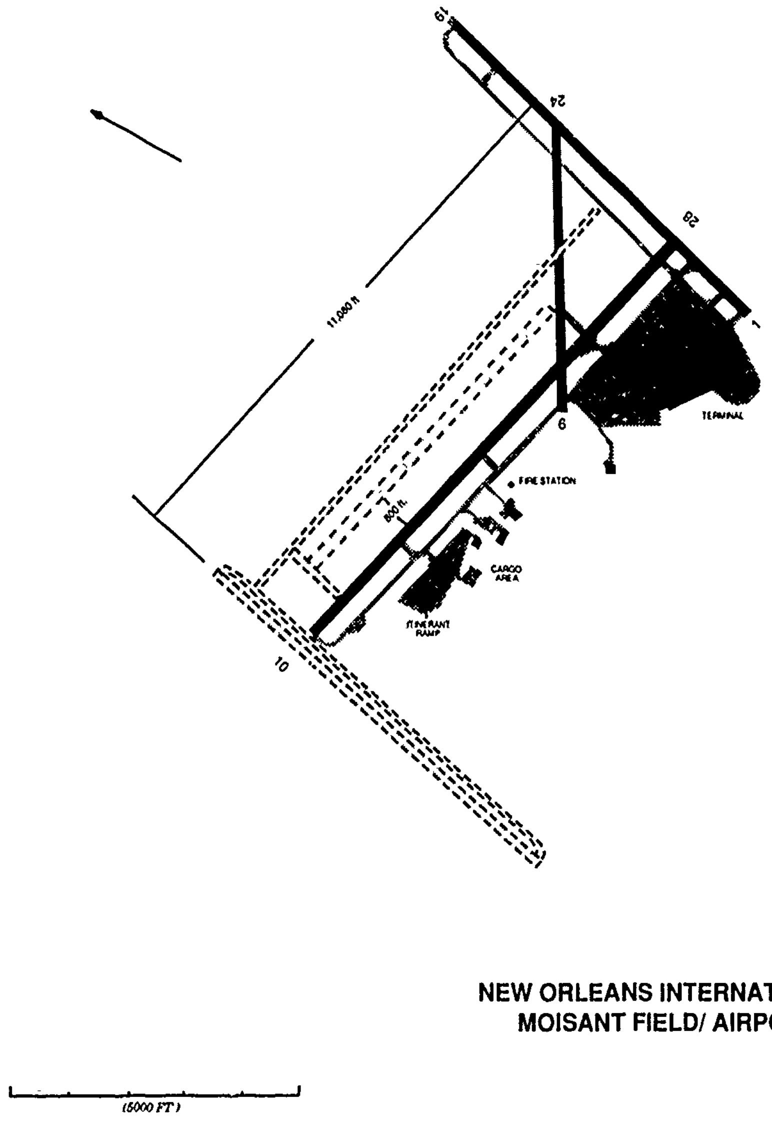
Runway 2R/20L was completed and became operational in November 1989 at Nashville. It is 9,000 feet long and is separatea from 2L/20R by 5,900 feet. The cost of construction was $78 million. Plans exist to extend Runway 2L/20R. Construction is expected to start in early 1991 and the runway should be operational in the summer of 1991. The cost of the extension is estimated at $39.8 million.



Revised 7/26/90

New Orleans (MSY)

A new north-south runway is planned. This new runway will be parallel to existing Runway 1/19 and will be located beyond the threshold of Runway 10, 8,000 feet away from Runway 1/19. This will allow independent parallel operations, doubling IFR hourly arrival capacity. Construction is planned to begin in January 1995 and be completed in 2000 at a cost of $160 million. The airport is also considering c nstruction of a 6,000-foot runway approximately 10,000 feet north of and parallel to Runway 10/28. An environmental assessment is expected to be initiated in FY 1991 or FY 1992. Construction is expected to begin in 1993 and should be completed in 1995 at a cost of $40 million. An extension of Runway 10/28 is currently being constructed and should be operational July 1991.

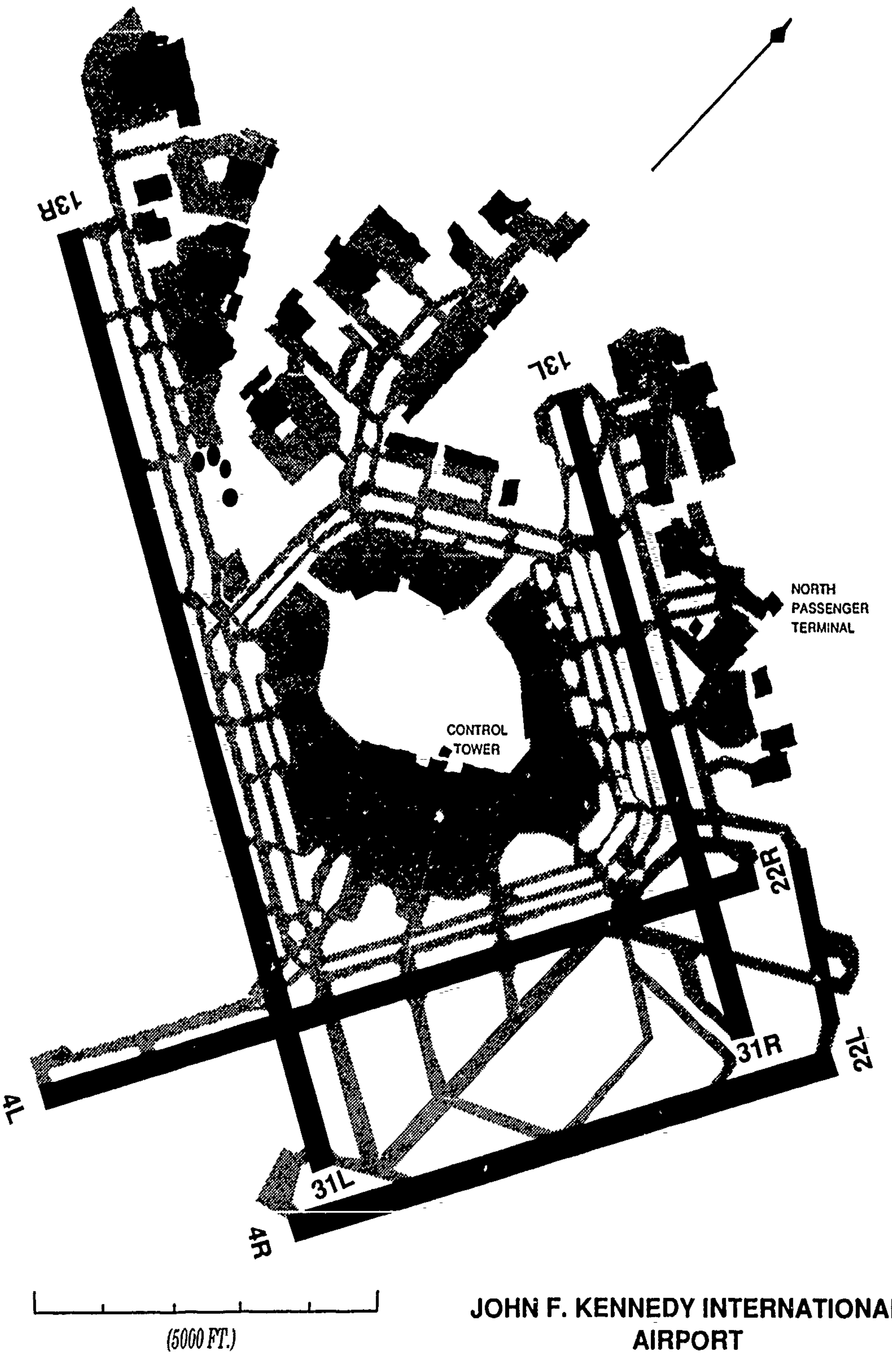


NEW ORLEANS INTERNATIONAL/
MOISANT FIELD/ AIRPORT

Revised 7/26/90

New York (JFK)

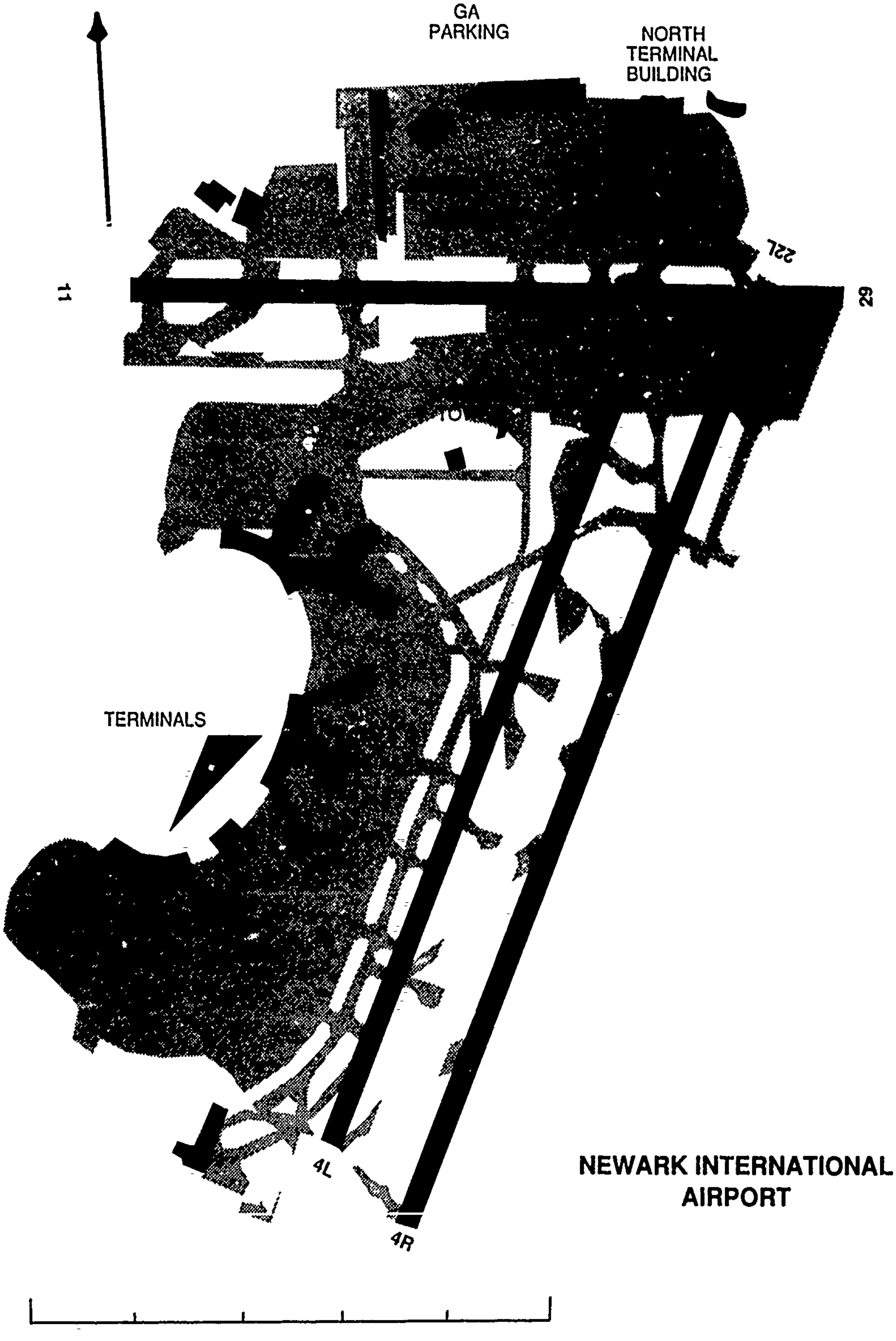
An extension to Runway 4L/22R is planned.



JOHN F. KENNEDY INTERNATIONAL AIRPORT

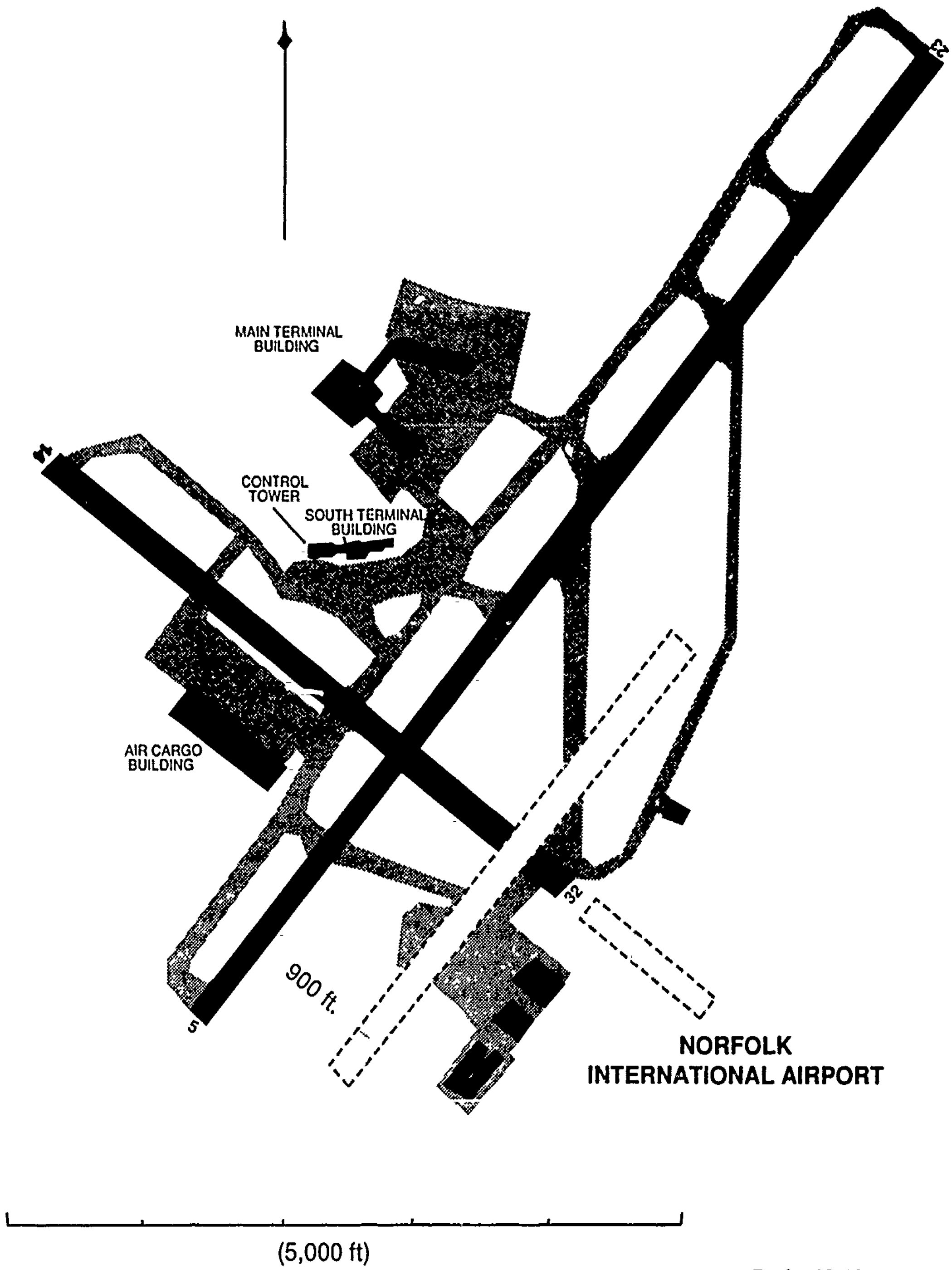
Newark (EWR)

A 500 foot extension to Runway 11/29 is planned.



Norfolk (ORF)

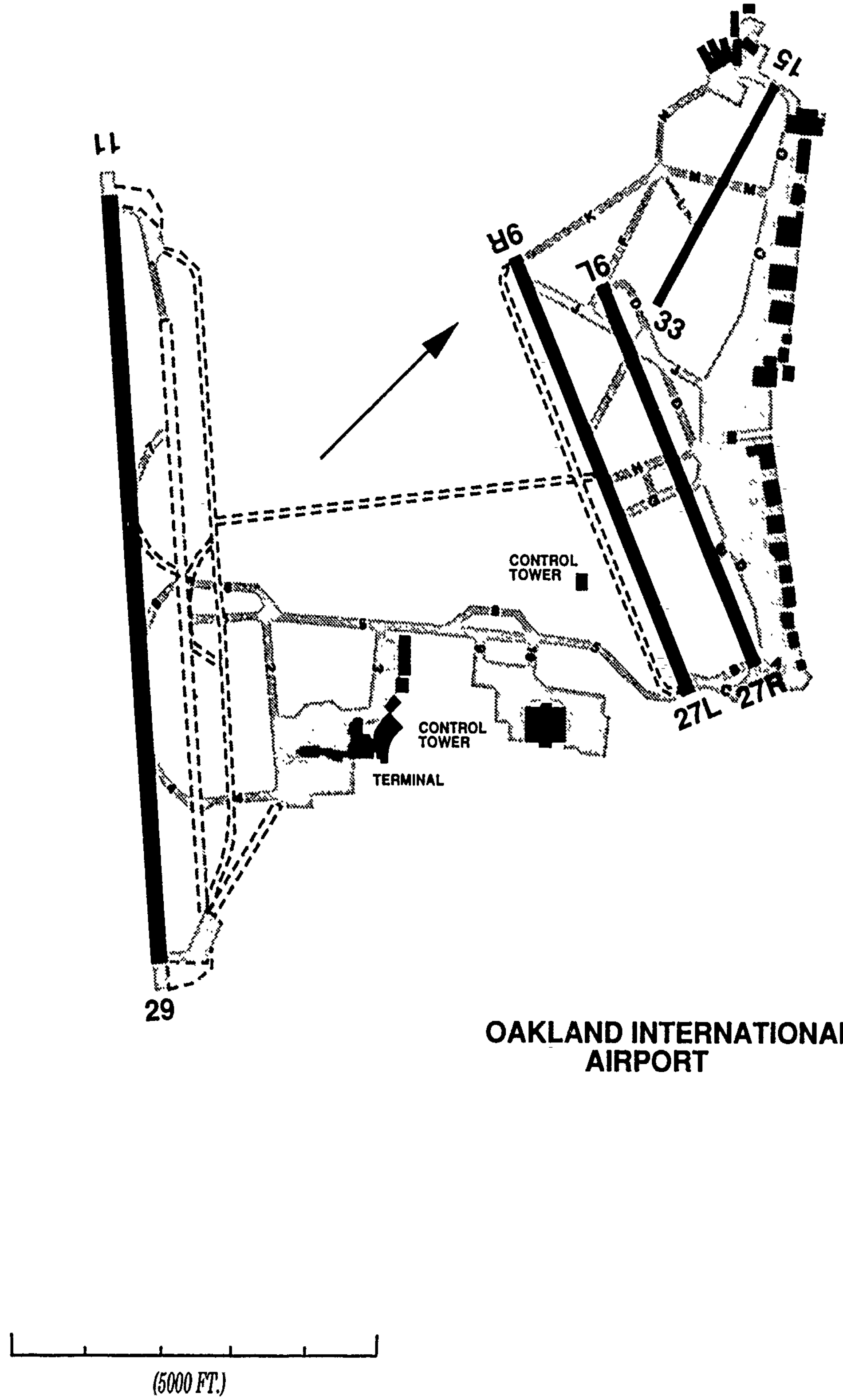
Runway 5R/23L, parallel to and 900 feet southeast of the main Runway 5/23, is being planned. Completion of this new parallel would not increase hourly IFR arrival capacity, but would add additional departure capacity. It is estimated that the runway will be operational in 1994 at a cost of $13 million. An extension to Runway 14/32 is also planned. The estimated cost is $2 million and the runway is expected to be operational in October 1996.



Revised 7/06/90

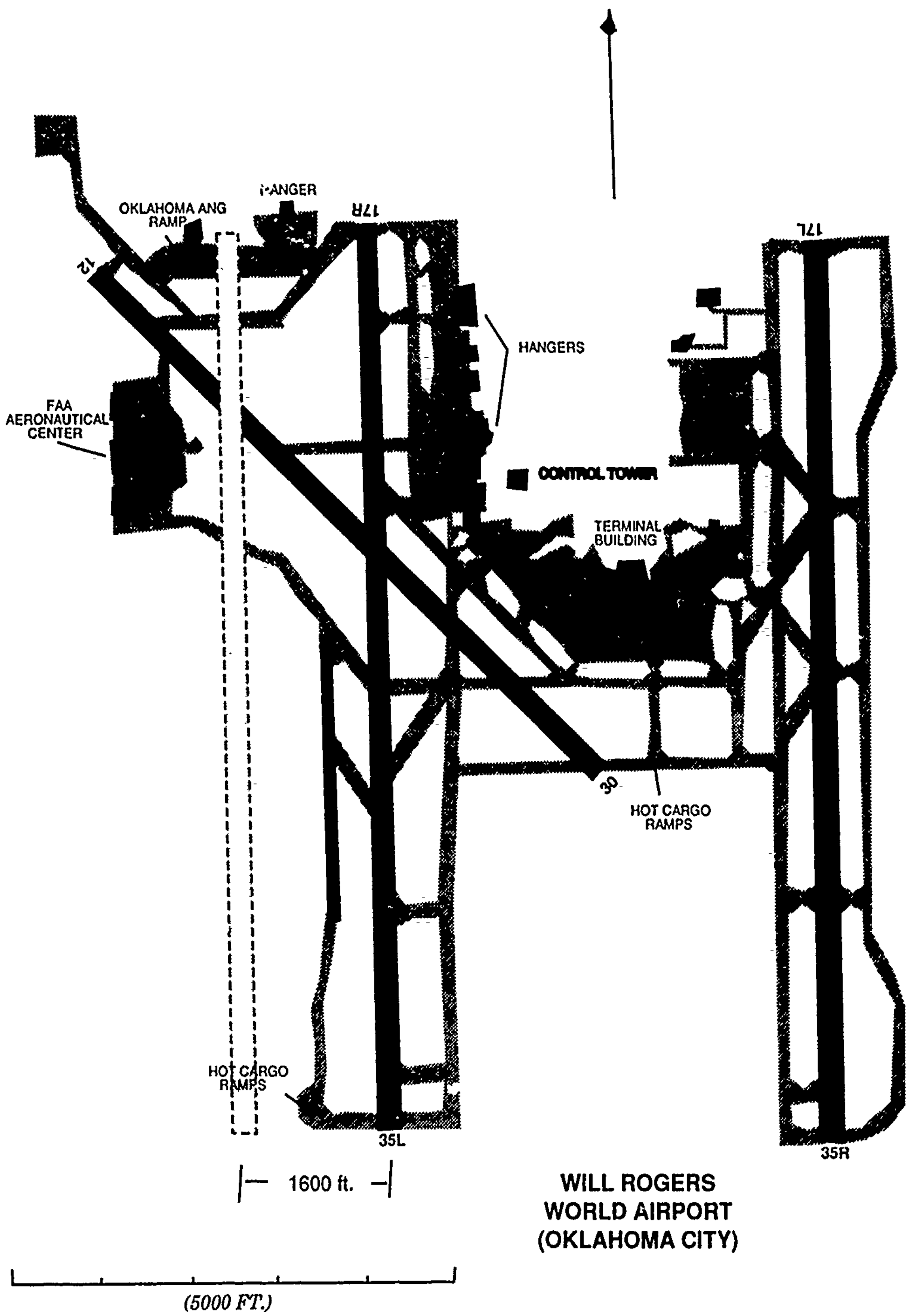
Oakland (OAK)

A new Master Plan is underway considering construction of a new air carrier runway, Runway 11R/29L. The estimated cost of construction is $143 million.



Oklahoma City (OKC)

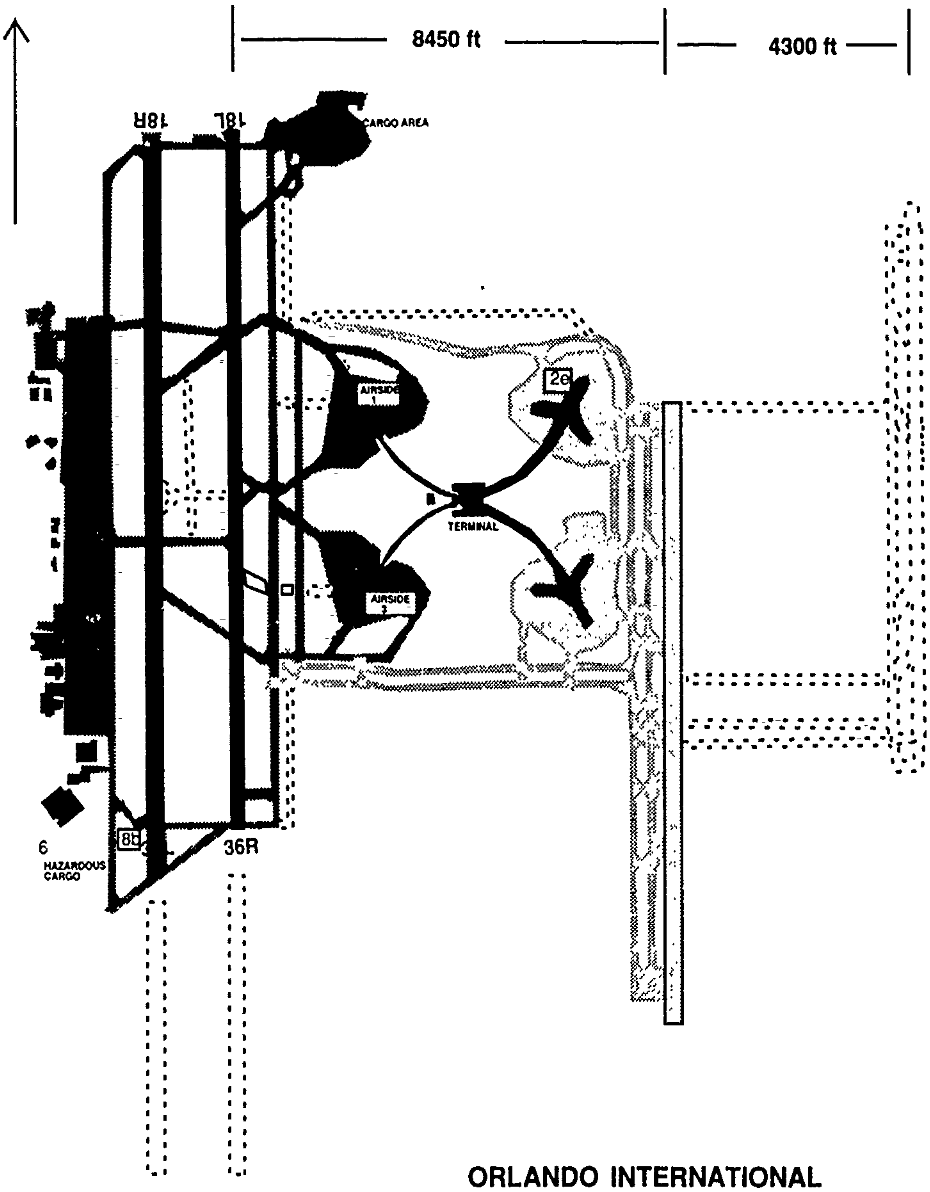
Extensions to both north-south runways to 12,500 feet are planned. It is anticipated that the extensions will be operational in 2001. The estimated cost of extending 17R/35L is $20 million; the estimated cost of extending 17L/35R is $24 million. Plans also exist for a 10,000 foot long parallel runway 1,600 feet west of 17R/35L. The estimated cost of construction is $55 million and the estimated operational date is October 2001.



Revised 7/26/90

Orlando (MCO)

A new parallel runway, Runway 17R/35L, became operational in September 1989. This should allow independent parallel IFR approaches, doubling hourly IFR arrival capacity. A fourth north-south runway, Runway 17L/35R, is expected to be operational in 1993. It will be located 4,300 feet east of the third runway, Runway 17R/35L. This may permit triple independent IFR operations. The estimated cost of construction of this runway is $80 million. A fifth runway, 17C/35C, has been proposed but does not appear in the Master Plan.



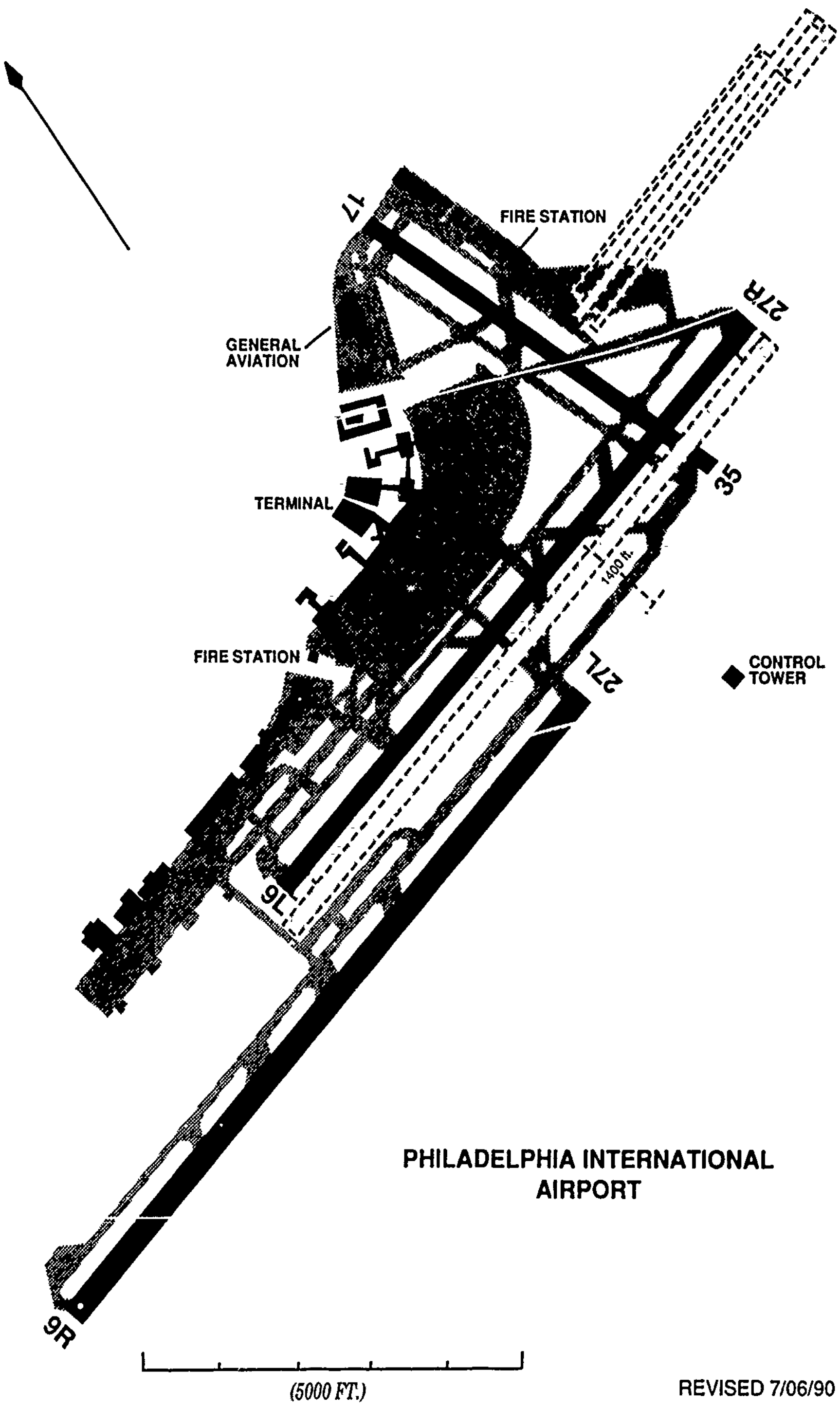
ORLANDO INTERNATIONAL AIRPORT

(5,000 ft)

REVISED 3/19/90

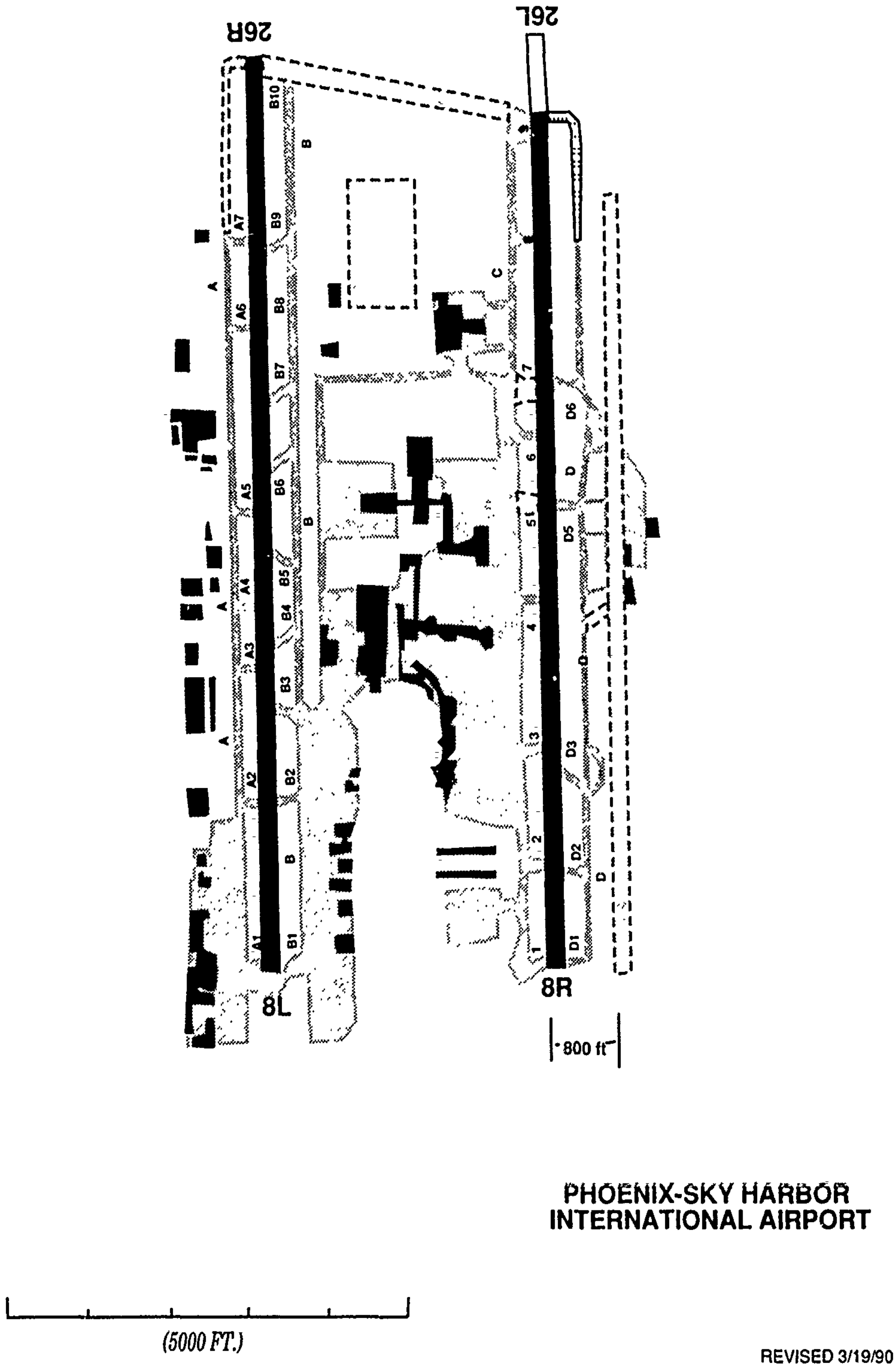
Philadelphia (PHL)

The inner parallel, Runway 9L/27R, will shift 600 feet south closer to Runway 9R/27L. A new 5,000 foot parallel commuter runway, Runway 8/26, has been proposed, to be located in the northeast quadrant. It could be spaced as wide as 4,300 feet from the relocated inner parallel. The location has not been established yet. This could potentially provide independent parallel IFR operations. The estimated cost of commuter Runway 8/26 is $100 million.



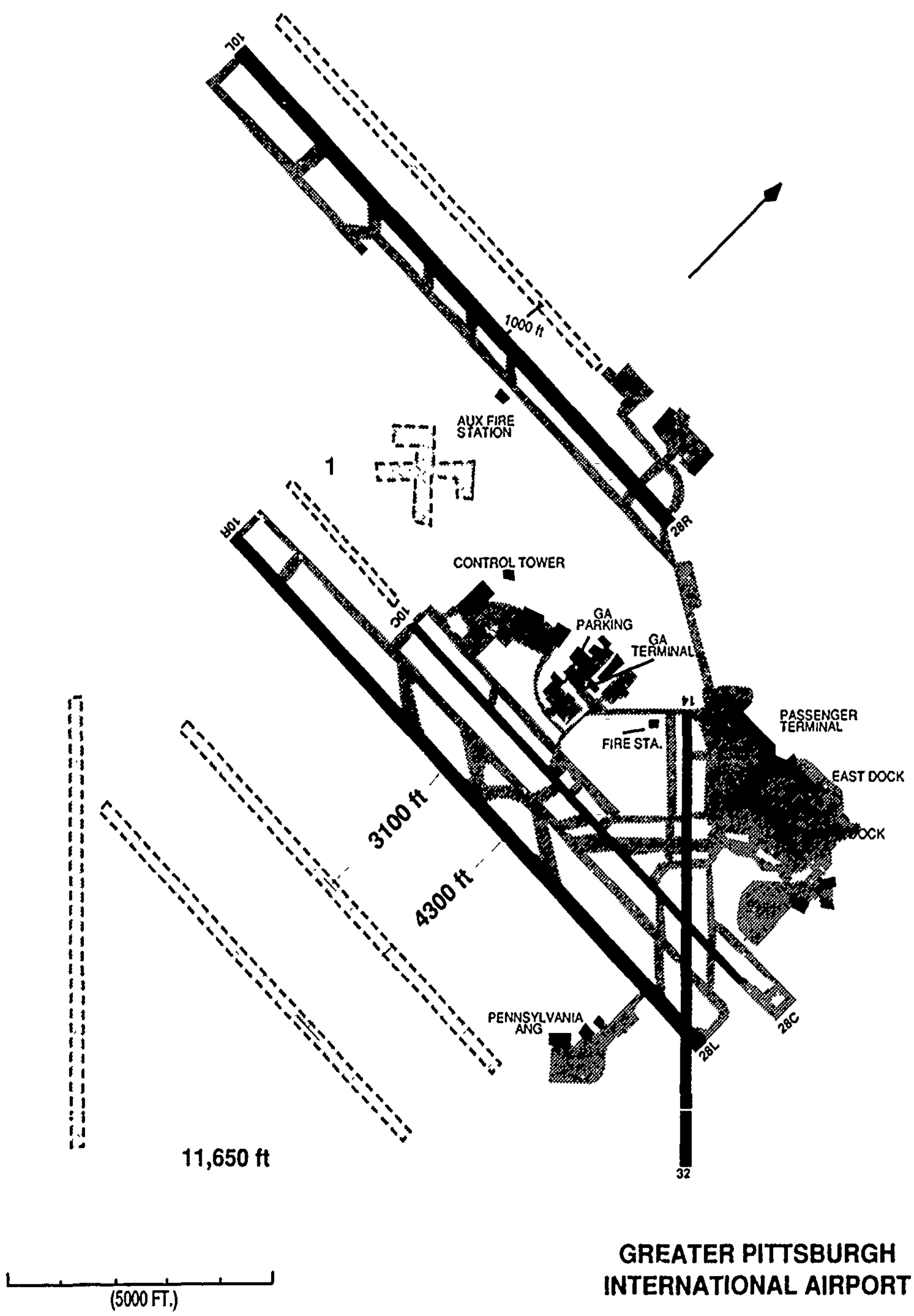
Phoenix (PHX)

A 9,500-foot third parallel runway, Runway 8S/26S, is proposed 800 feet south of Runway 8R/26L. The cost of construction is estimated to be $88 million. An environmental assessment of this third runway is underway and is expected to be submitted during the third quarter of FY91. The estimated operational date is 1994.



Pittsburgh (PIT)

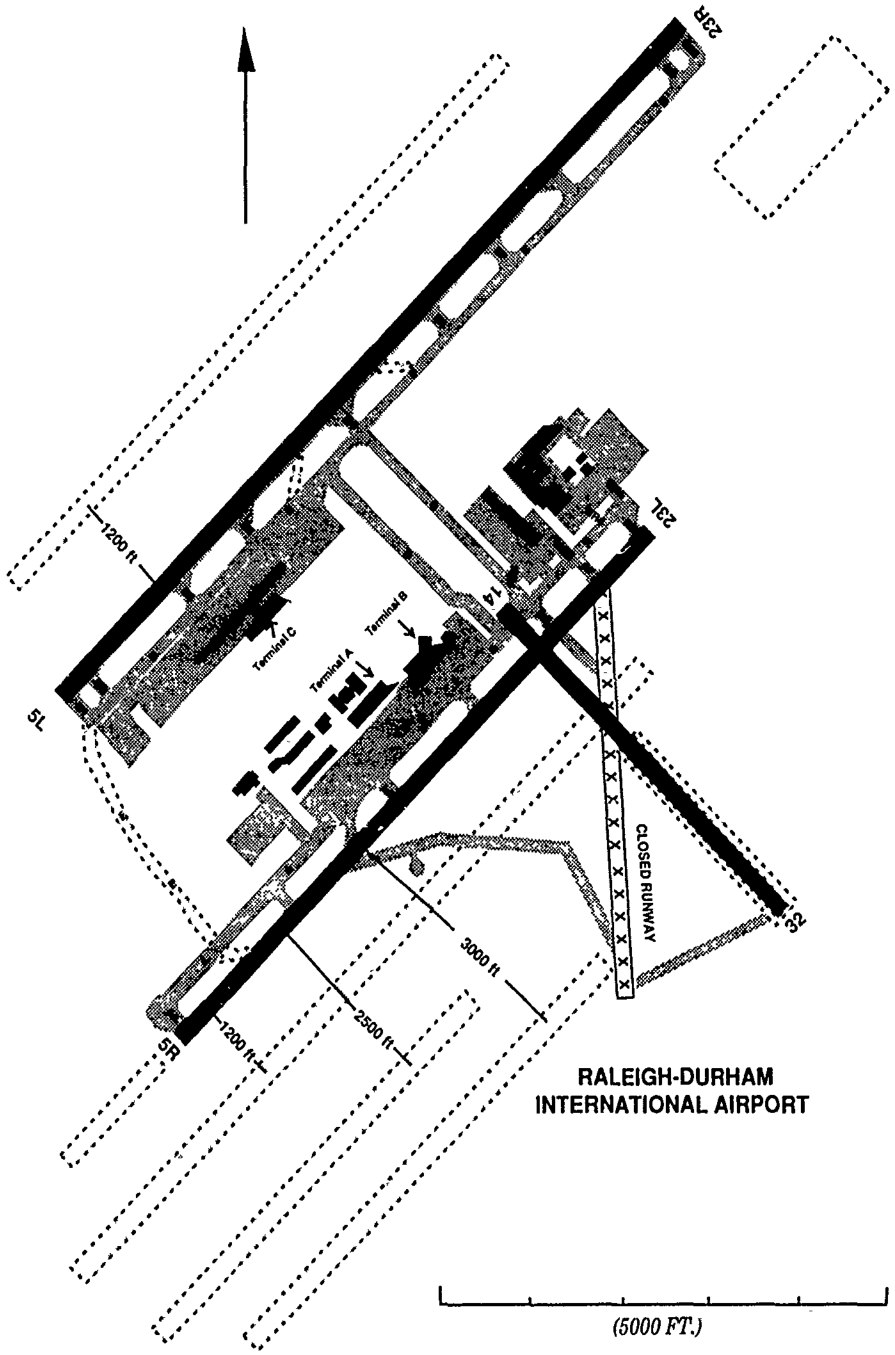
A new Master Plan will start in 1990. It will recommend a choice between a new parallel crosswind runway and a fourth 10/28 parallel. Construction of Runway 14R/32L, parallel to existing crosswind 14/32, is tentatively scheduled to begin in June 1993 and be completed in 1995. It will be located more than 11,650feet from the existing crosswind runway. The fourth 10/28 parallel runway may take higher priority. It is also currently scheduled to begin in 1993, and be completed in 1995. Completion of the fourth parallel may permit triple independent IFR approaches.



GREATER PITTSBURGH INTERNATIONAL AIRPORT

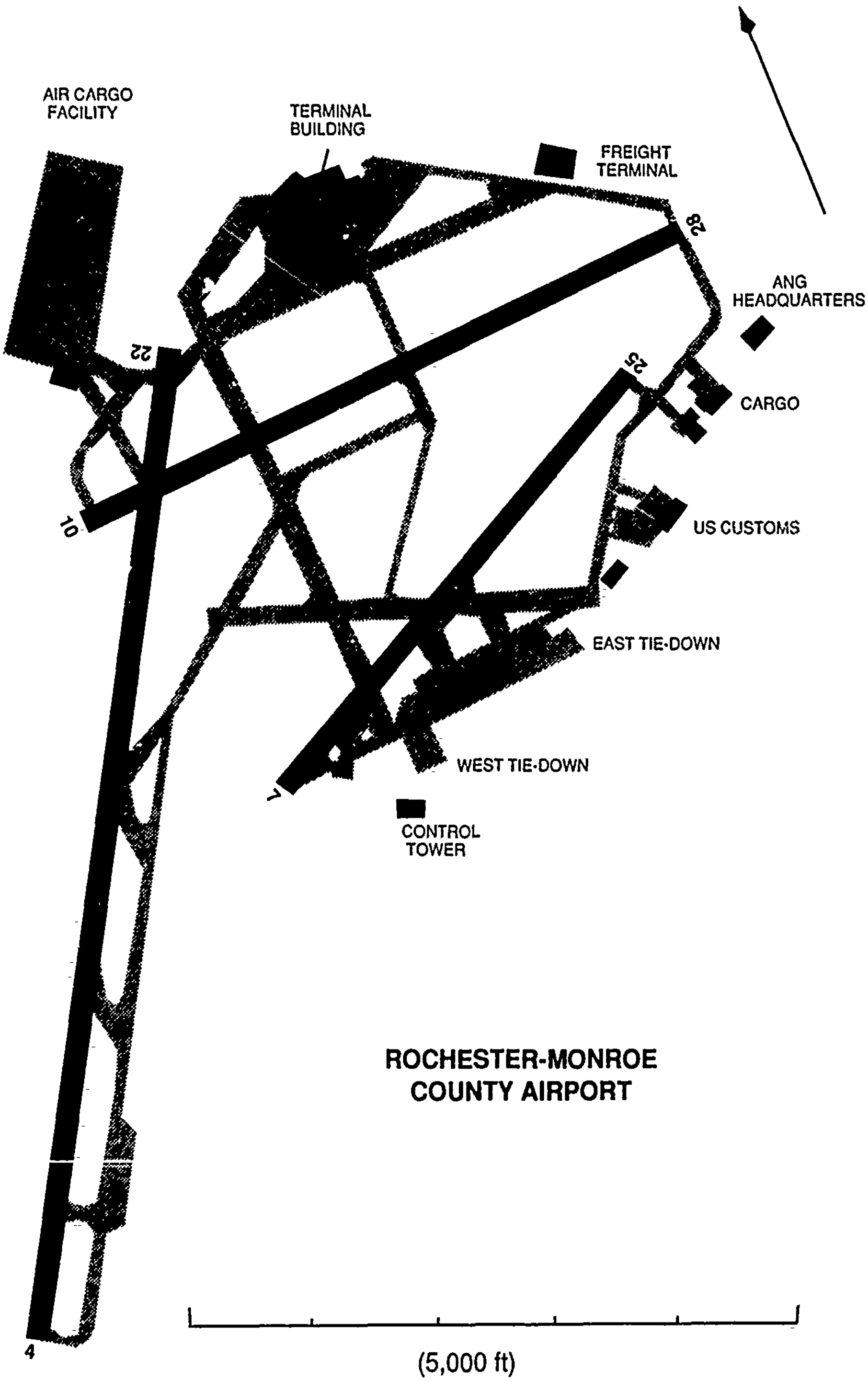
Raleigh-Durham (RDU)

The relocation of Runway 5R/23L and associated taxiways is expected to begin in 1993. The new runway will be parallel to and approximately 1,200 feet southeast of existing Runway 5R/23L. It will be a 9,000-foot long air carrier runway and could permit independent IFR approaches. The estimated operational date is 1996 and the estimated cost is $45 million. Two other runways are proposed for eventual construction. One is a parallel commuter runway, southeast of the existing Runway 5R/23L. The other would be a parallel runway approximately 1,200 feet southwest of Runway 5L/23R.



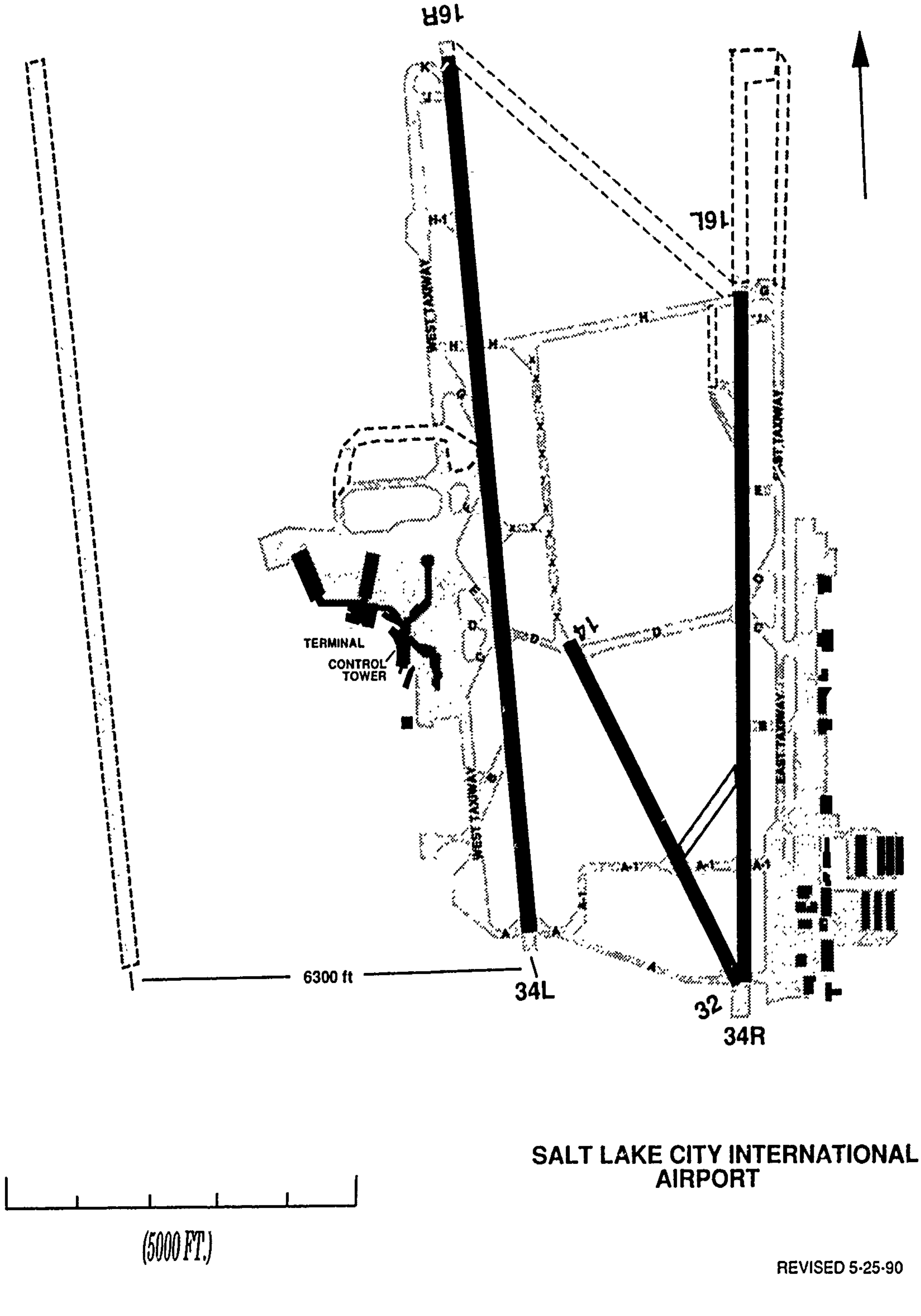
Rochester (ROC)

Construction is expected to begin on an extension to Runway 10/28 in 1993, to be completed in 1994. The estimated cost of construction is $2.3 million. An extension to Runway 4/22 is expected to cost $0.5 million. Construction will begin in 1995 and the extension should be operational in 1996. Parallel Runway 4R/22L is estimated to cost $4.7 million and should also be operational in 1996. Environmentals assessments have not yet been started for these projects.



Salt Lake City (SLC)

A new 12,000 foot runway parallel to and 6,300 feet west of existing 16R/34L is planned. Construction is scheduled to begin in 1991 and should be completed in 1994. The estimated cost of construction is $95 million. This may permit triple IFR approach operations, if approved.

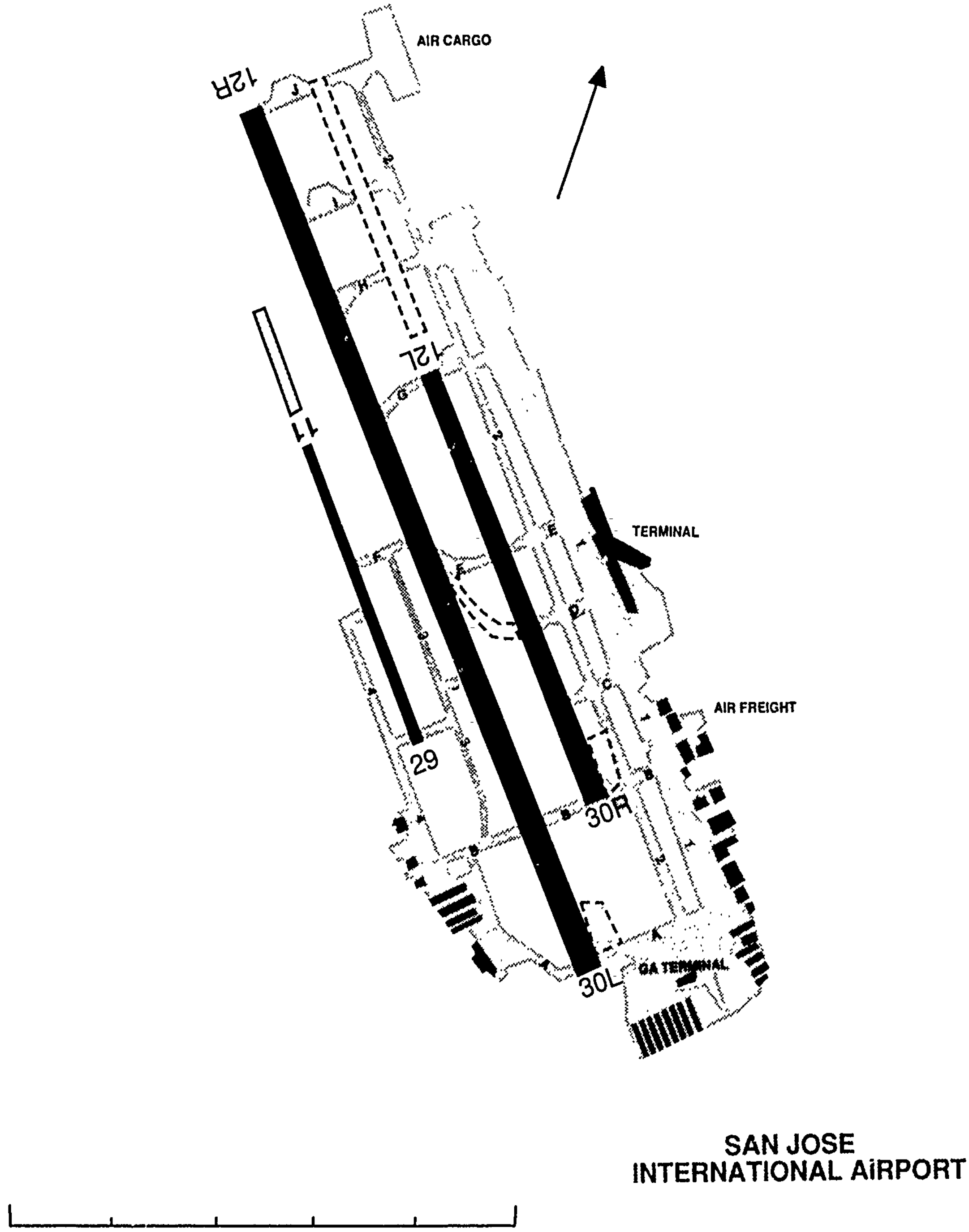


SALT LAKE CITY INTERNATIONAL AIRPORT

REVISED 5-25-90

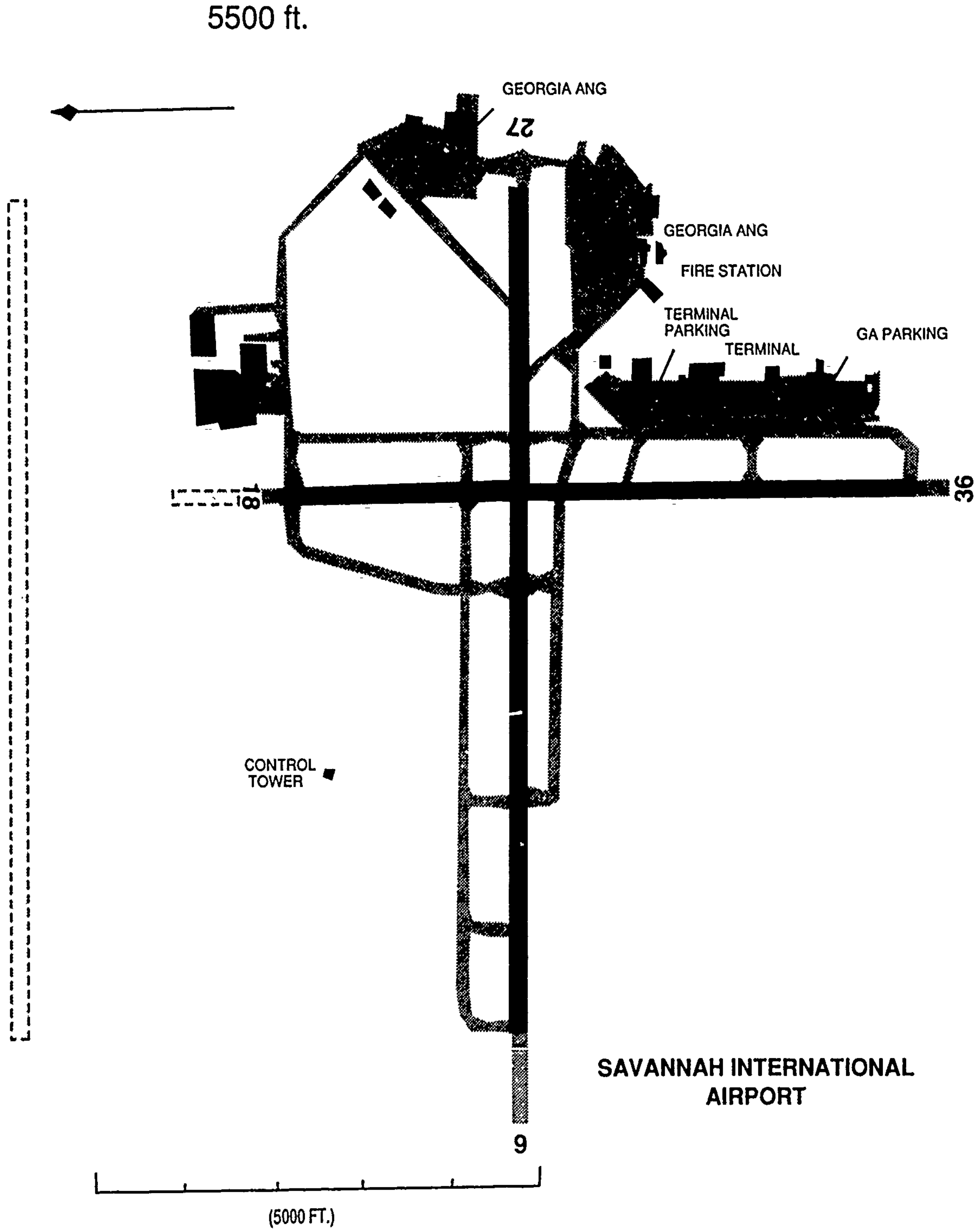
San Jose (SJC)

A new 4,600-foot runway, 700 feet southwest of Runway 30L/12R, to replace the existing Runway 11/29 was completed late in 1989. Consideration is also being given to extend 30R/12L for air carrier capability. The estimated cost of construction of the extension is $10 million.



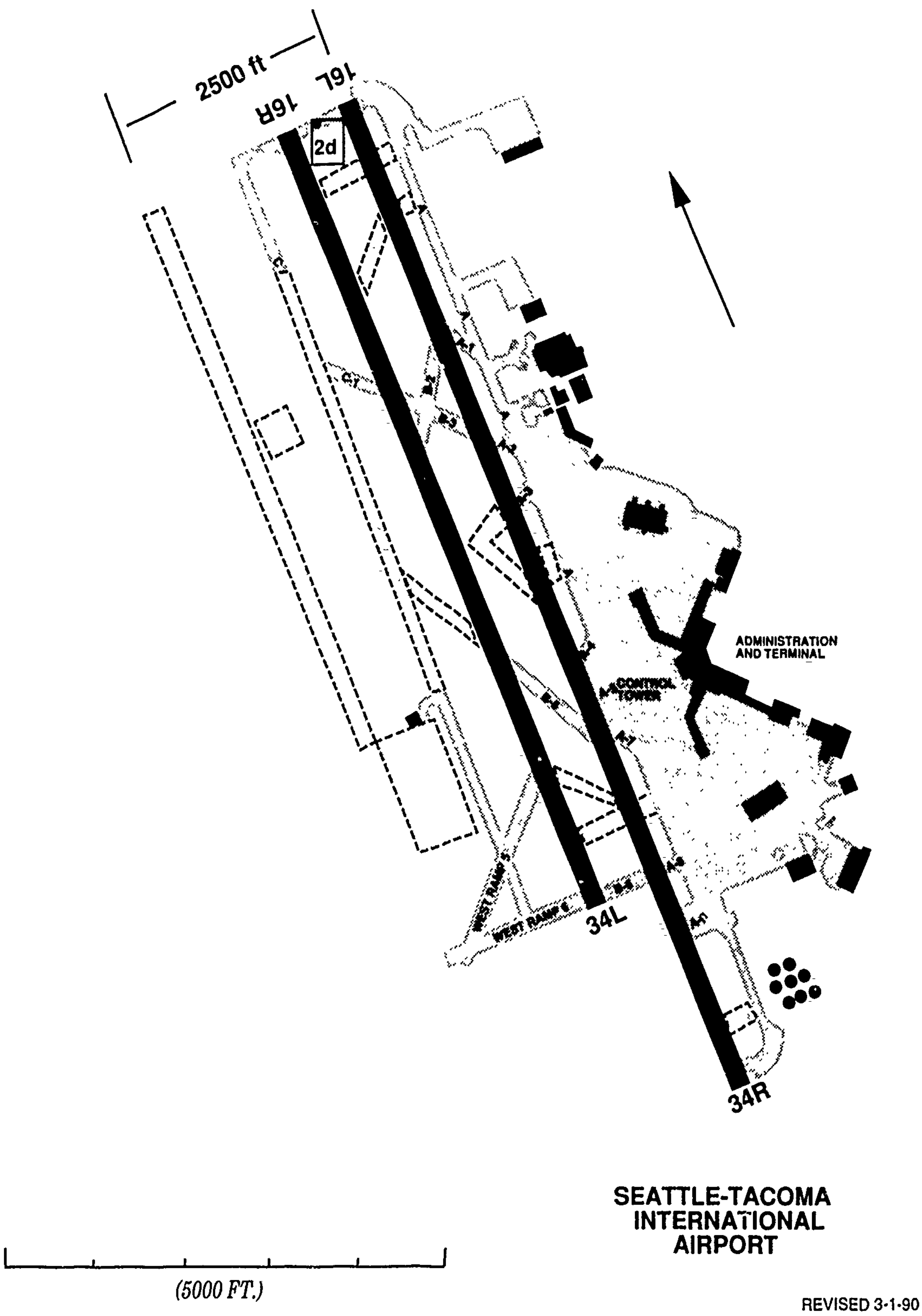
Savannah (SAV)

Two runway construction projects are being planned. A 1,000 foot extension to Runway 18/36 is expected to begin in 1994 and should be completed in 1995 at a cost of $3.9 million. A new 9,000 foot long parallel runway, Runway 9L/27R, is shown on an airport layout. Construction is expected to begin in 2009 and should be completed in 2010 at a cost of $20 million.



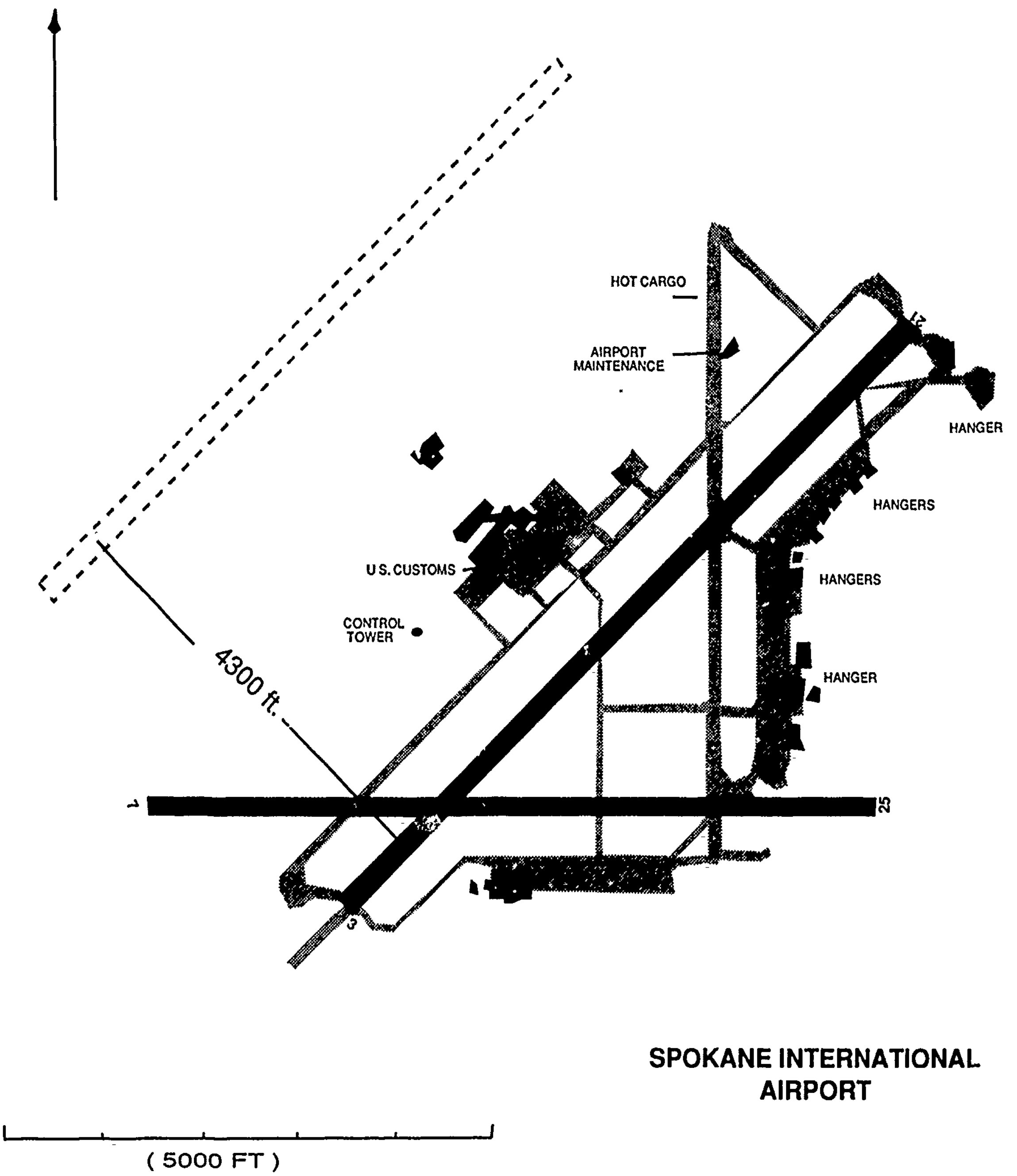
Seattle (SEA)

Potential airport improvements include a new 7,000-foot runway, Runway 16W/34W, to be located 2,500 feet from Runway 16L/34R.



Spokane (GEG)

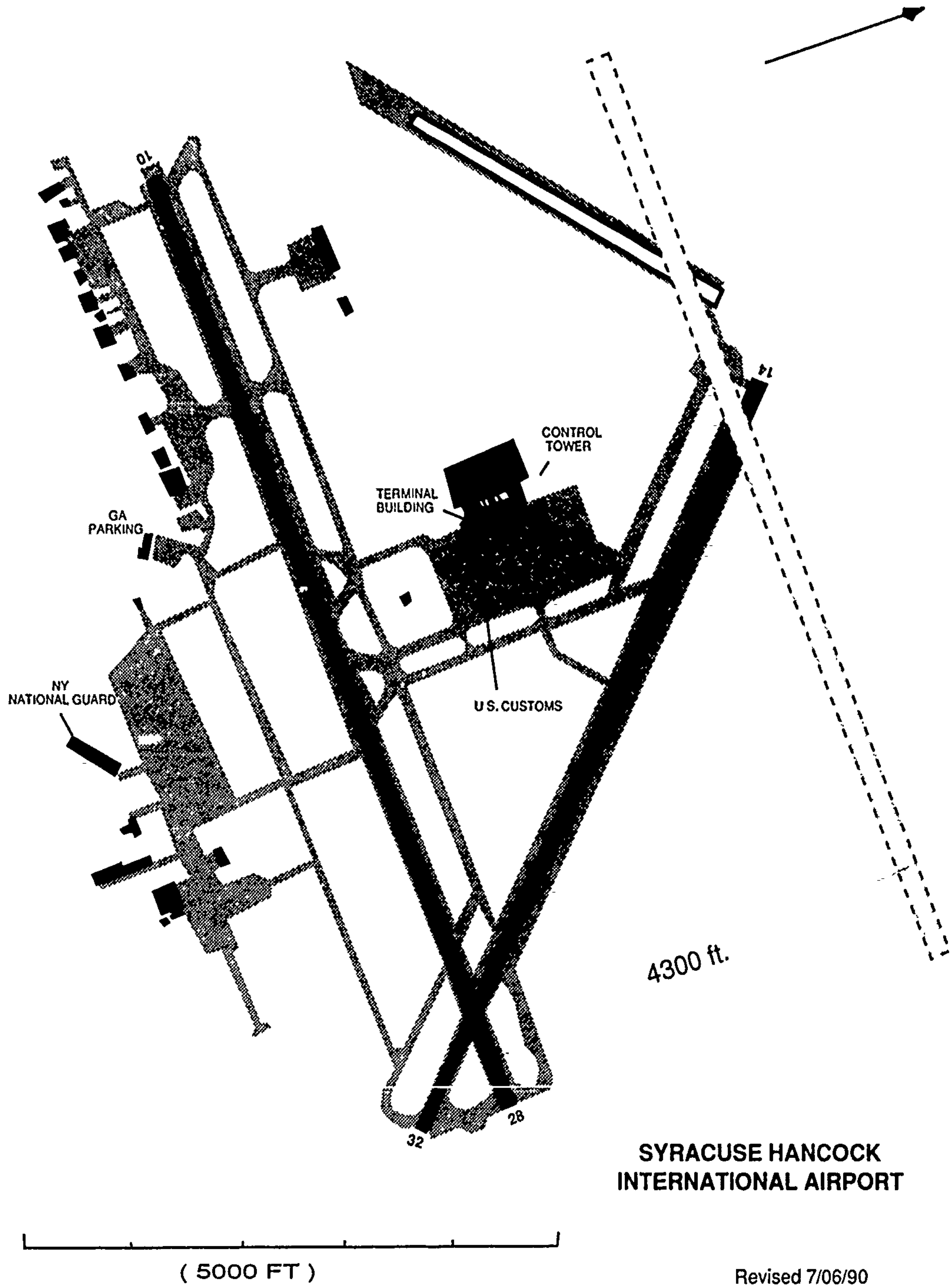
Future projects for capacity enhancement include the construction of a parallel runway, Runway 3L/21R. The new runway will be 8,800 feet by 150 feet, and will be separated from Runway 3R/21L by 4,300 feet. This would enable independent parallel operations, doubling hourly IFR arrival capacity. The estimated cost of construction of the new runway is approximately $11 million. Construction is expected to start in 1995 and should be completed in 1996.



REVISED 6/29/90

Syracuse (SYR)

There is a potential for a parallel Runway 10L/28R, 9,000 feet long, and separated from the existing Runway 10/28 by 4,300 feet. This would provide independent parallel IFR operations, doubling hourly IFR arrival capacity. The expected operational date is sometime in 1997 if construction starts in 1996 as anticipated. The cost of construction is estimated to be $5 million.

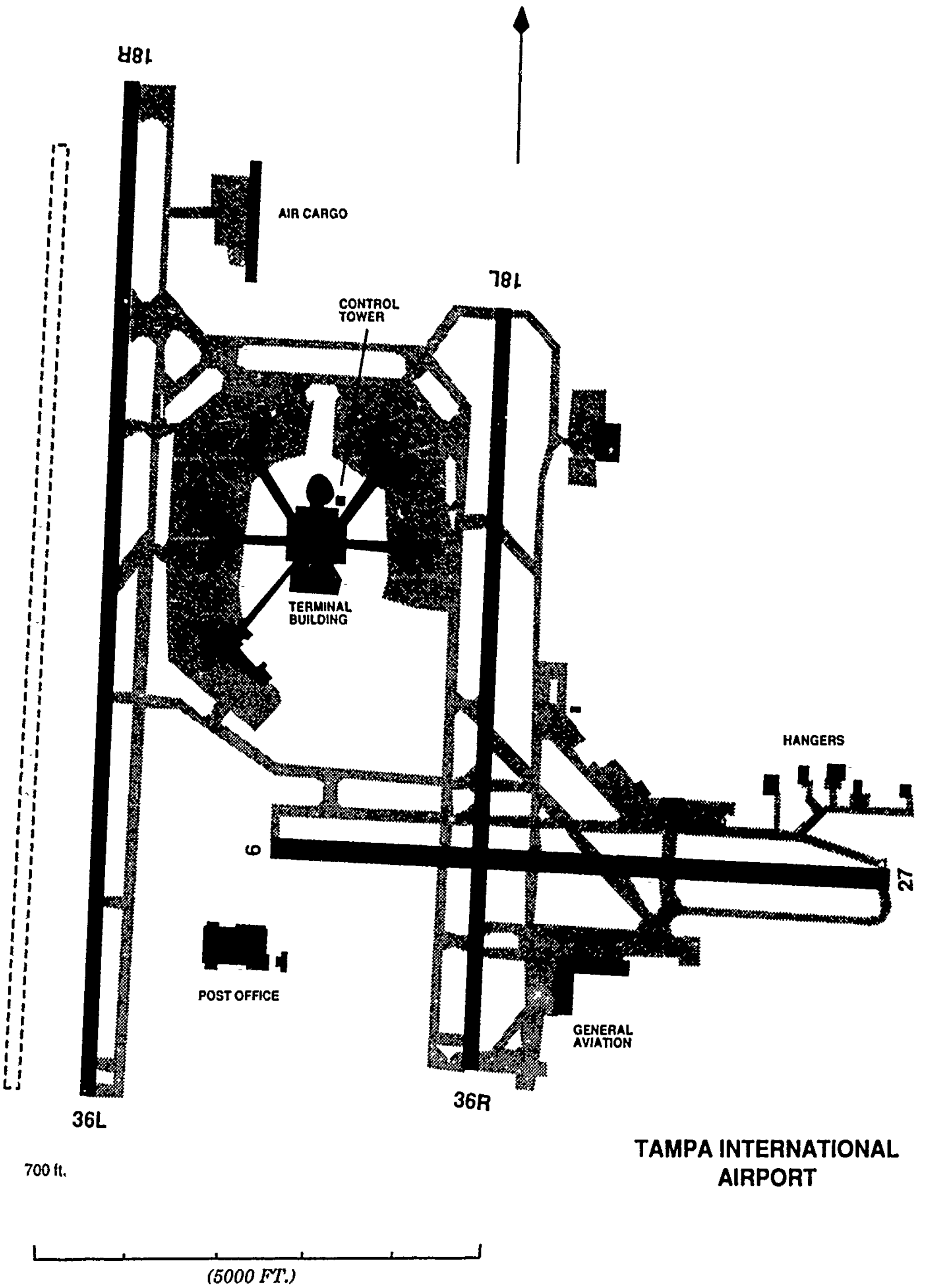


SYRACUSE HANCOCK
INTERNATIONAL AIRPORT

Revised 7/06/90

Tampa (TPA)

Plans have begun for a third parallel runway, Runway 18R/36L. The new runway will be 700 feet west of Runway 18R/36L and 9,650 feet long. Construction is planned to start in 1995. The estimated operational date for the runway is 1997 at a cost of $53 million. No increase in hourly IFR arrival capacity will be provided; however, VFR capacity will increase as well as IFR departure capacity.

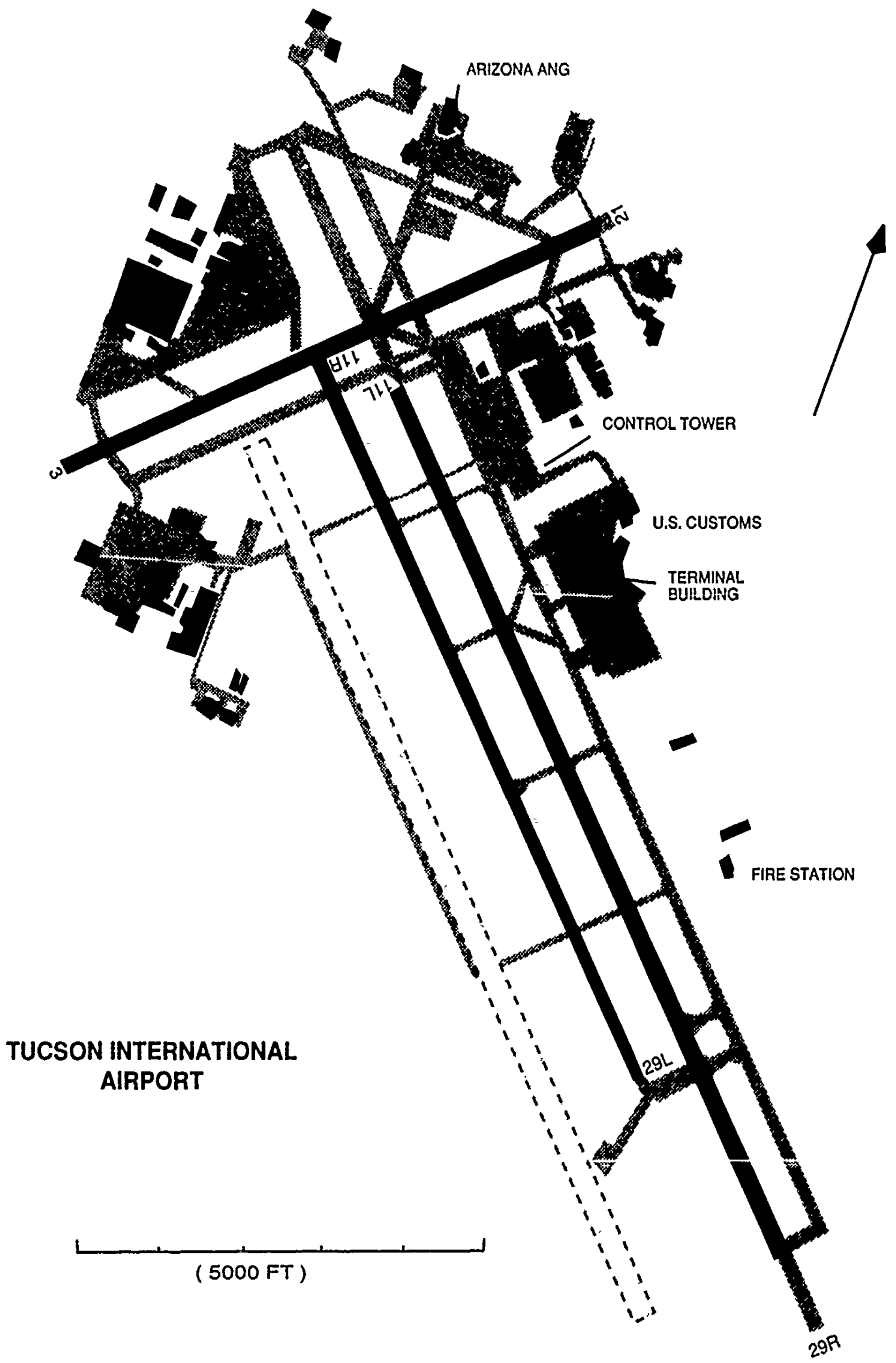


TAMPA INTERNATIONAL AIRPORT

Revised 7/06/90

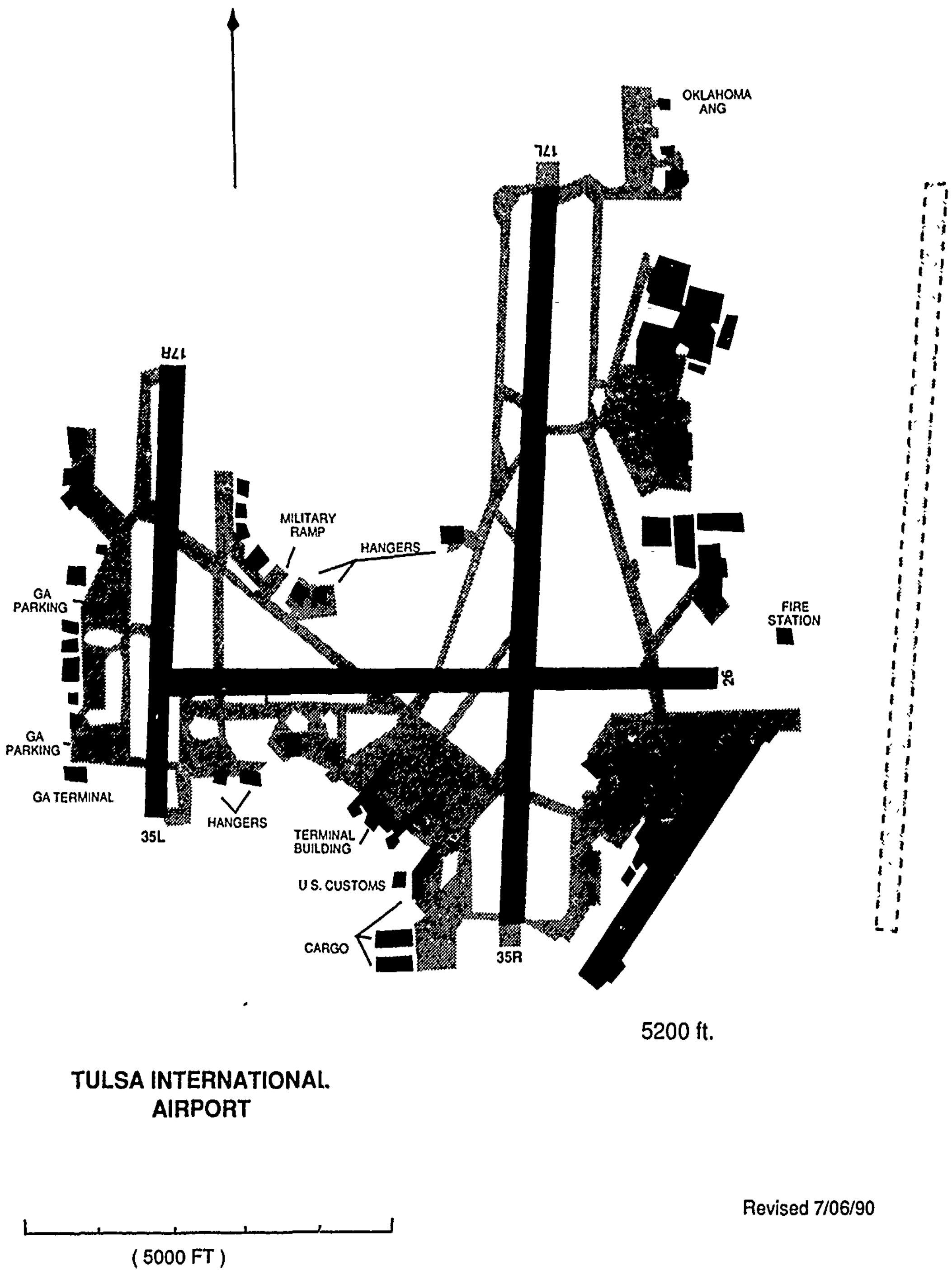
Tucson (TUS)

An additional parallel air carrier runway, Runway 11R/29L, has been proposed. Upon completion of the new runway, the current Runway 11R/29L, a general aviation runway, will revert to its original taxiway status. It is not anticipated that the sponsor will proceed before 1993-1995.



Tulsa (TUL)

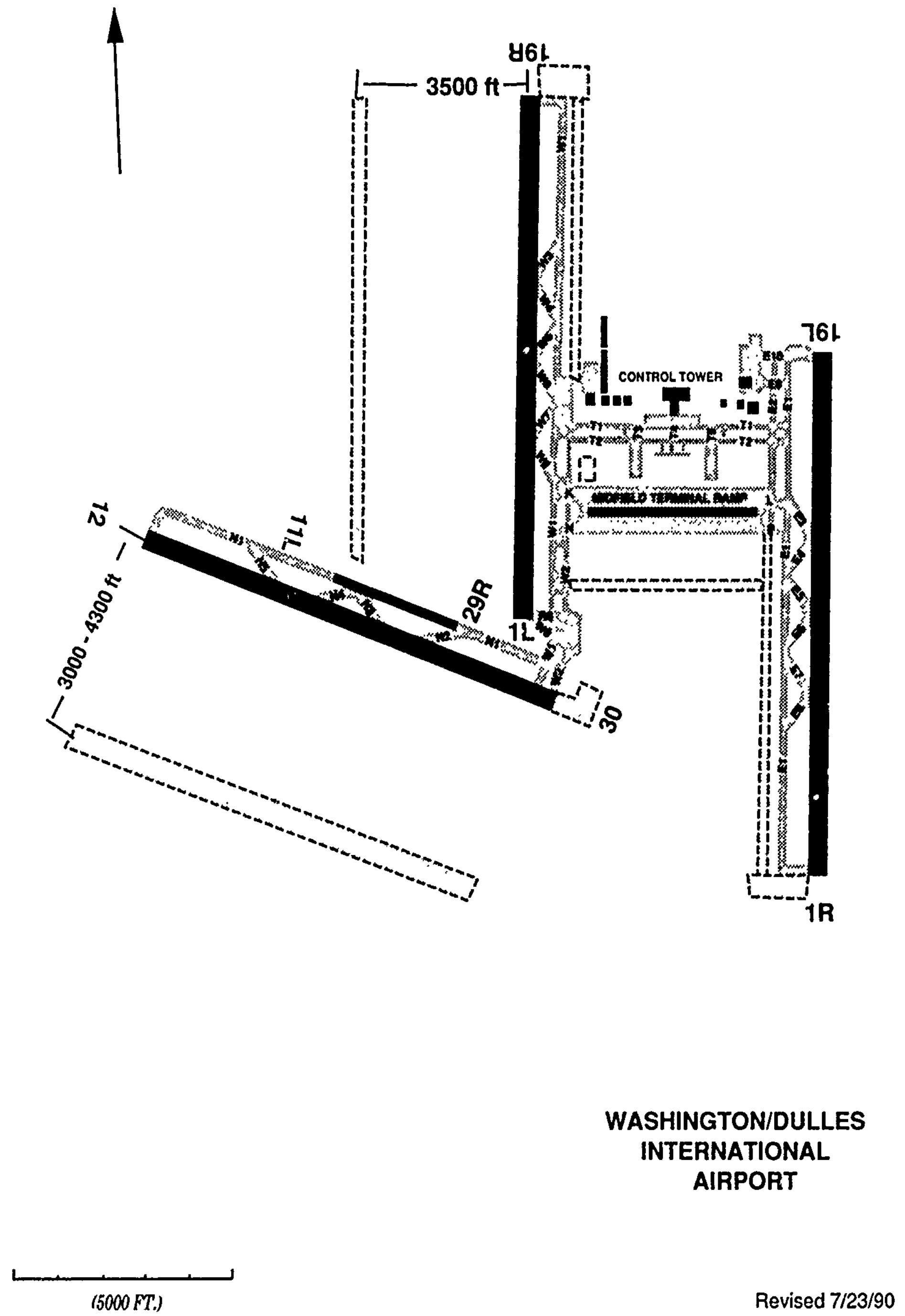
A new parallel runway, Runway 17L/35R, is planned to be located 5,200 feet east of the present 17L/35R and will be 9,600 feet long. The estimated operational date is 1998. The cost of the new runway is estimated to be between $80 and $100 million. The new runway could permit IFR triple independent approaches, if approved, to Runways 17L, 17C, and 17R.



Revised 7/06/90

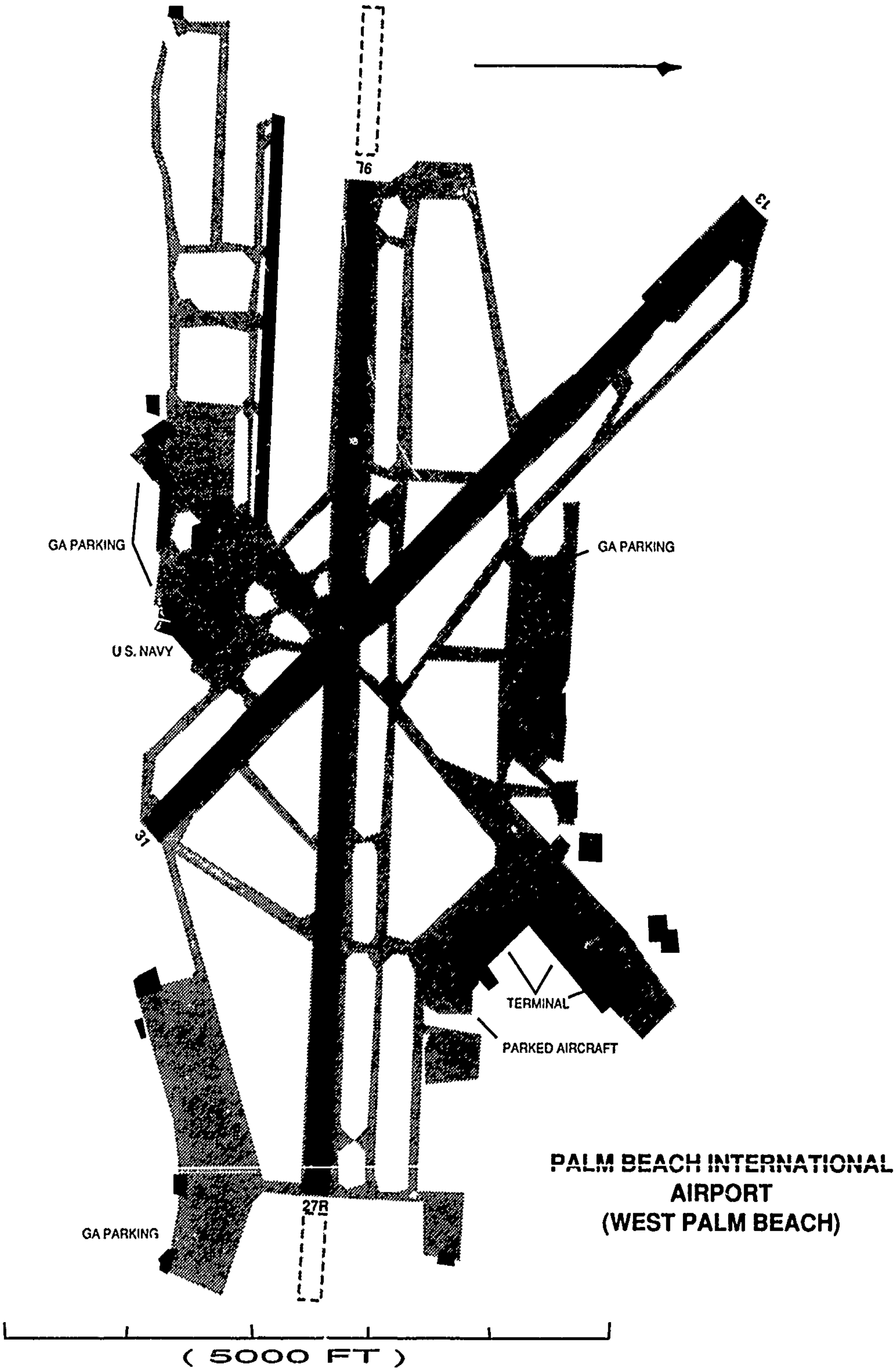
Washington (IAD)

Construction of an extension to Runway 12/30 is expected to begin in 1991 and should be completed in 1992. The estimated cost of construction is $7.2 million. Two new parallel runways are under consideration. A north-south parallel, Runway 1W/19W is planned, to be located 3,500 feet west of the existing parallels, and north of Runway 12/30. This could provide triple independent parallel approaches, if approved. Construction is expected to begin in 1999. A second parallel is proposed for location 3,000 - 4,300 feet south of Runway 12/30.



West Palm Beach (PBI)

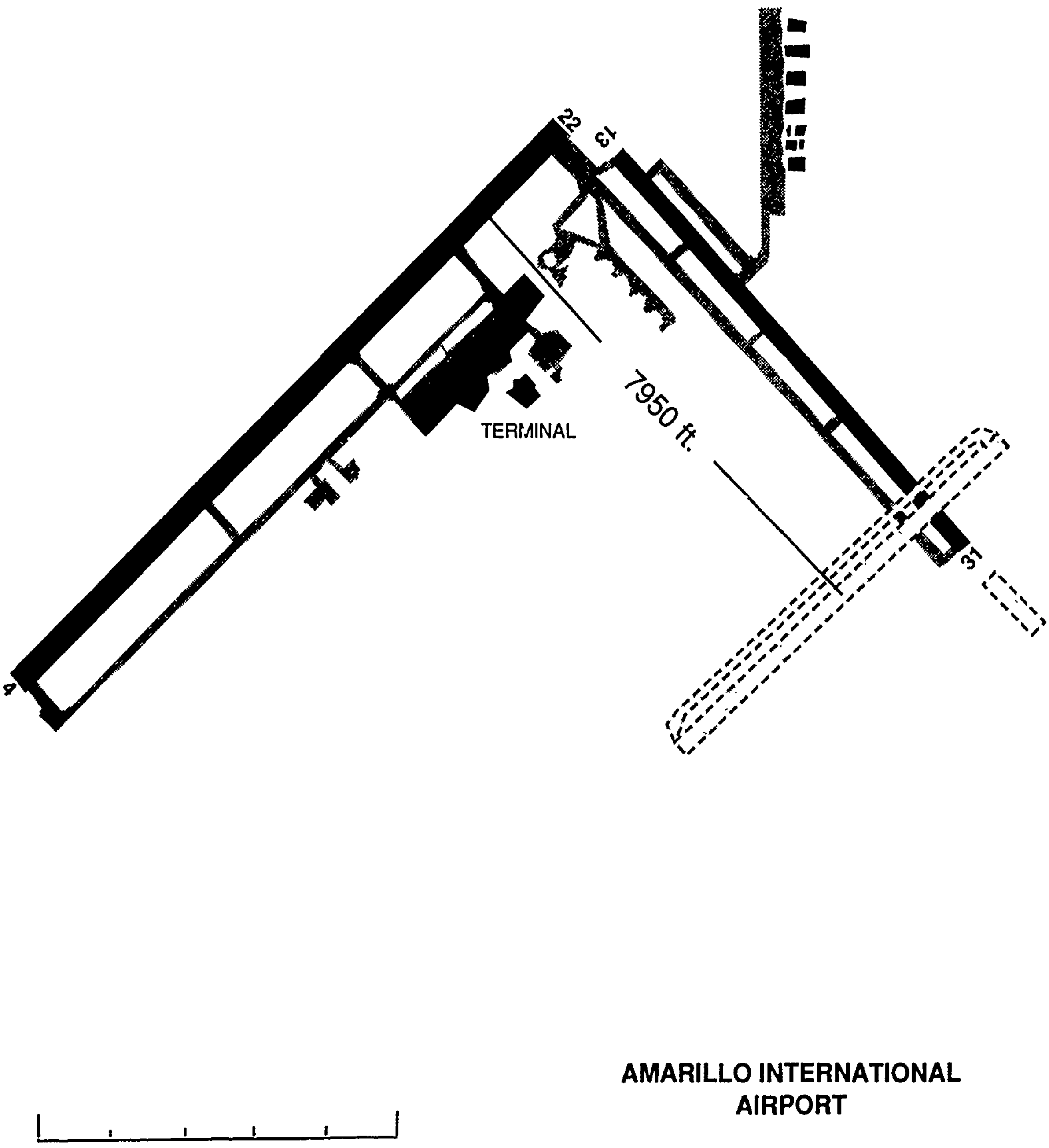
The environmental process to extend Runway 9L/27R on both ends has been completed. The runway will be extended 1,200 feet to the west and 811 feet to the east, for a total length of 10,000 feet. Construction is estimated to be completed within the next 5 years. The total estimated project cost is $3.5 million.



Appendix D

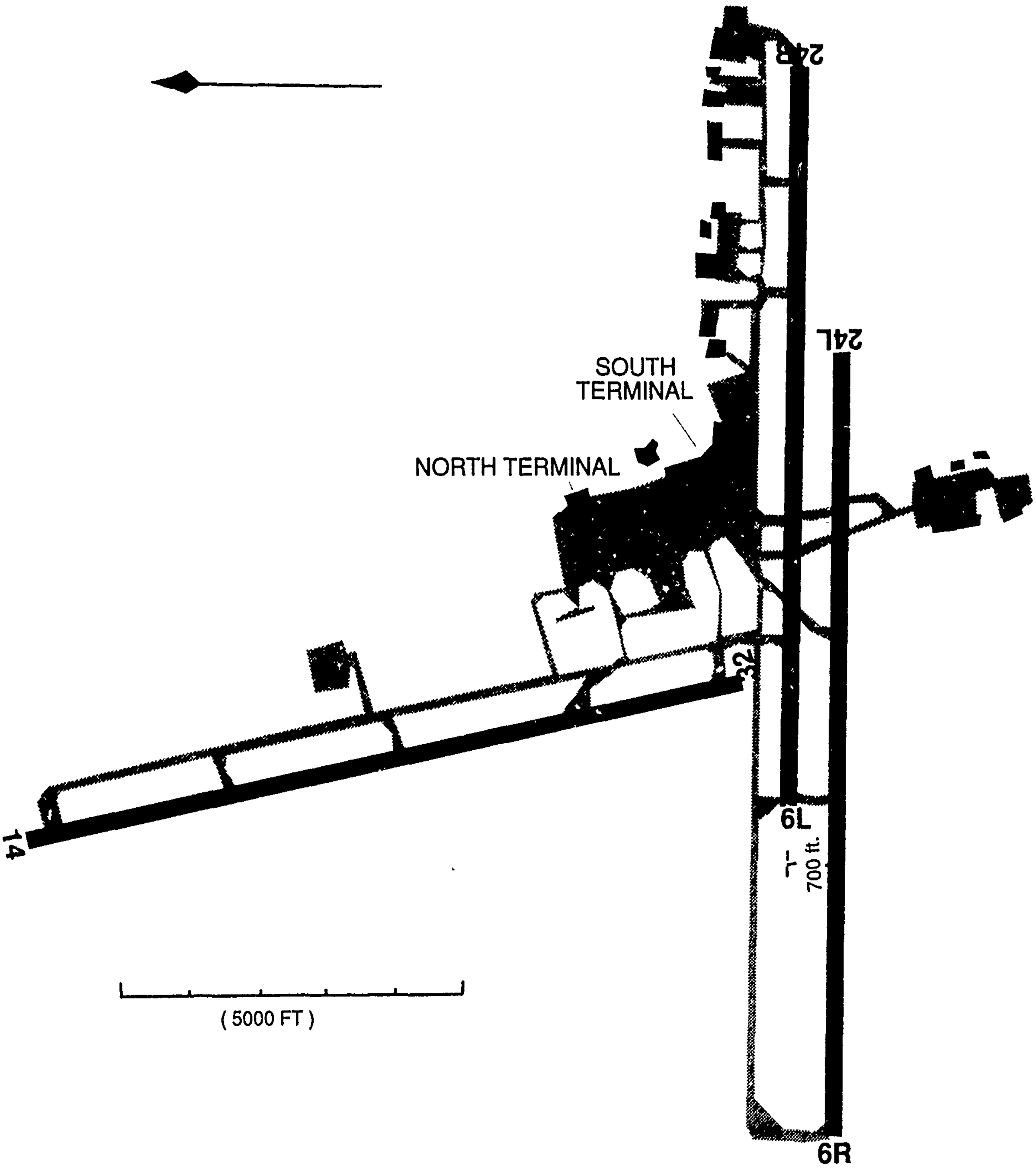
Layouts of the Remaining 100 Airports[1]

1. All 100 airports are pictured in either Appendix B, Appendix C, or Appendix D.



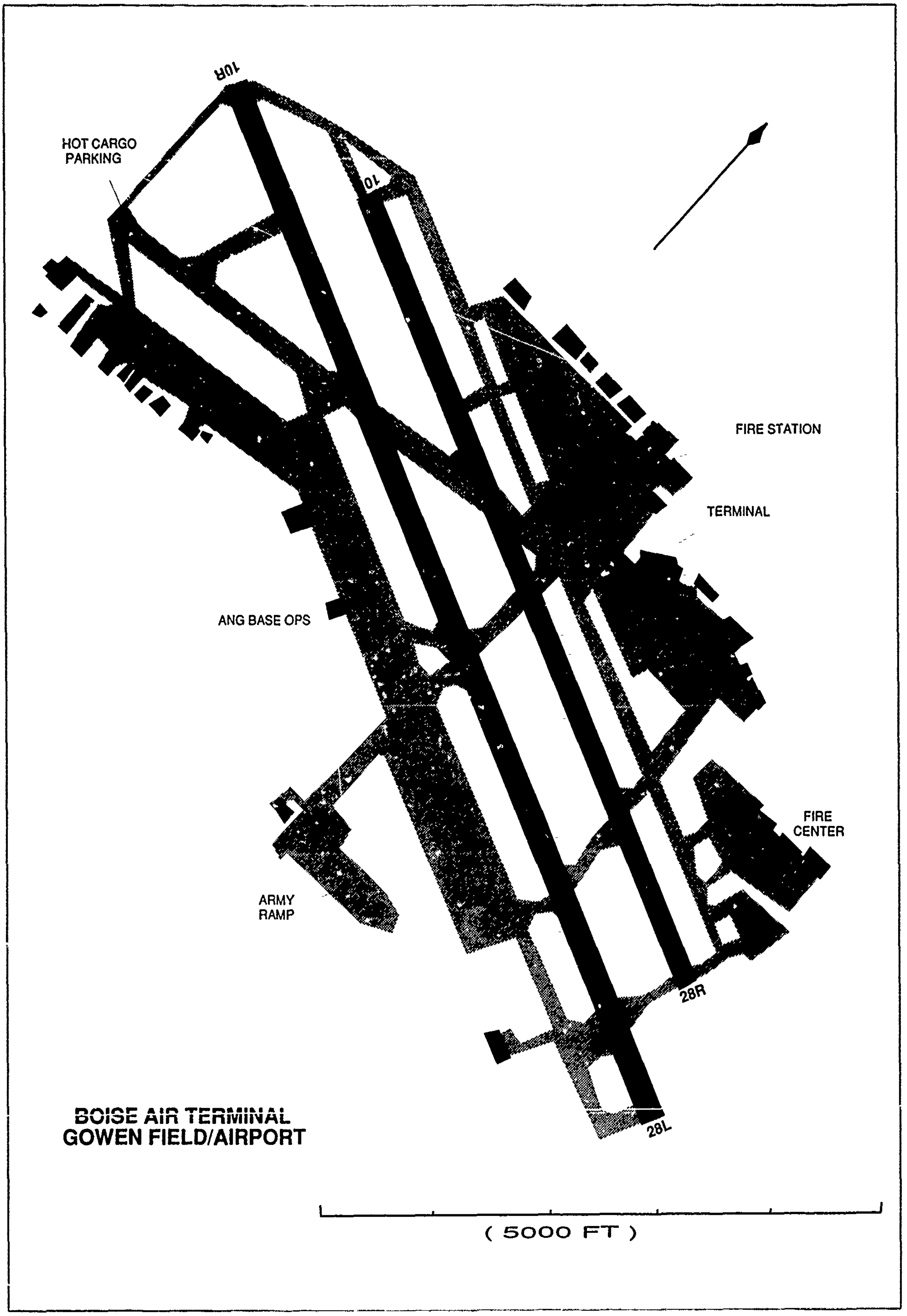
AMARILLO INTERNATIONAL AIRPORT

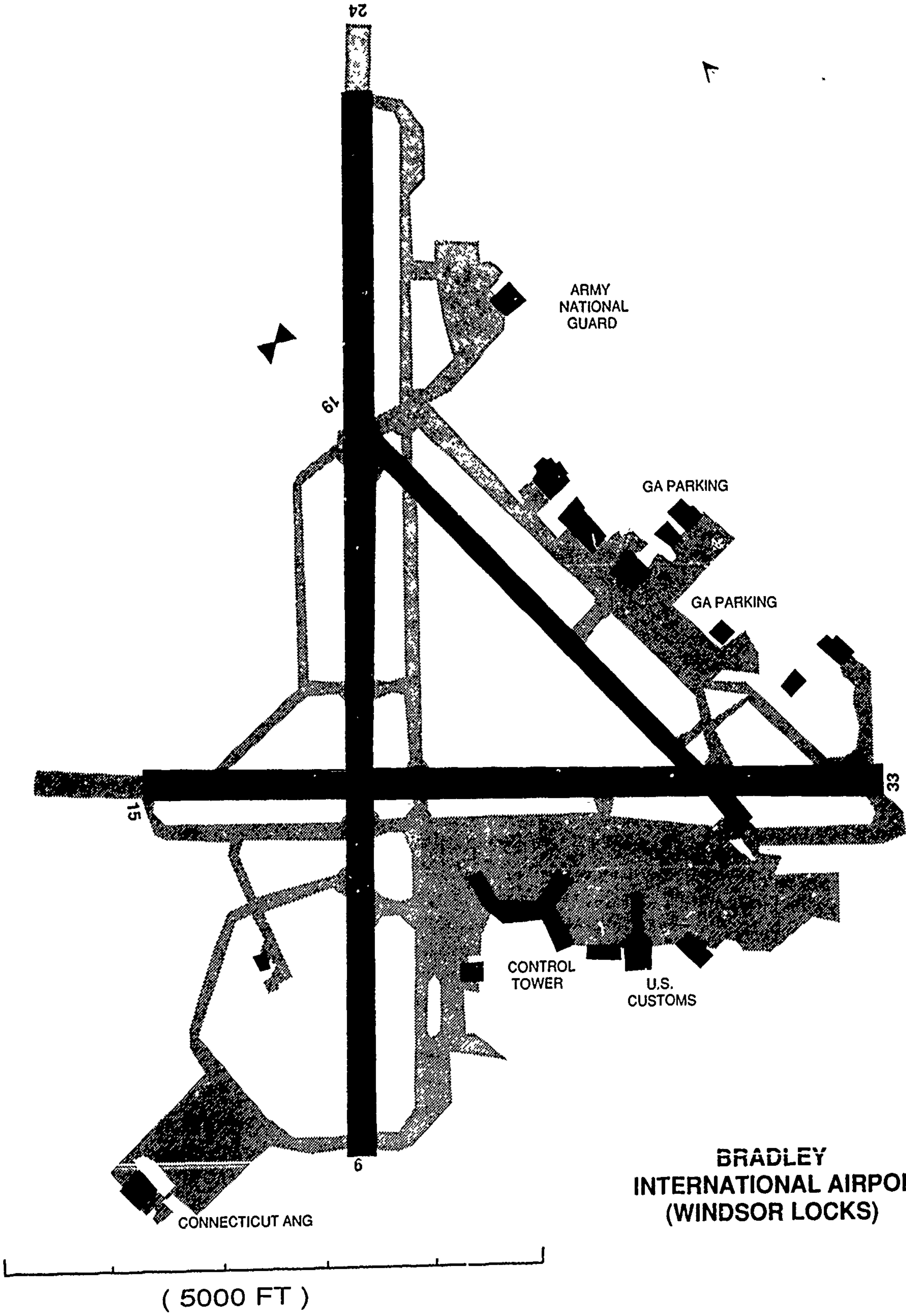
Revised 7/06/90



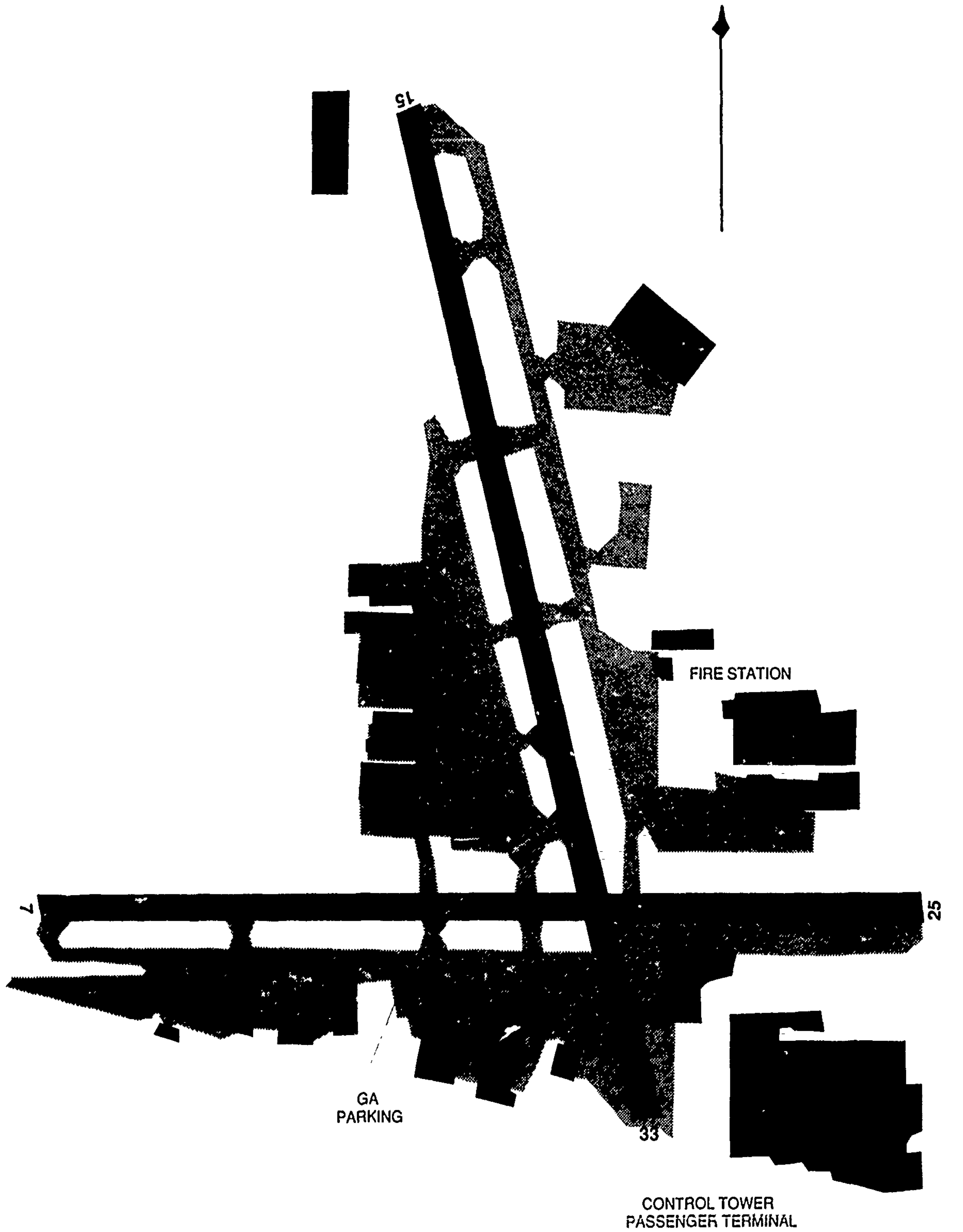
ANCHORAGE INTERNATIONAL AIRPORT

Revised 7/06/90


10R
HOT CARGO PARKING
10L
FIRE STATION
TERMINAL
ANG BASE OPS
FIRE CENTER
ARMY RAMP
28R
28L
BOISE AIR TERMINAL
GOWEN FIELD/AIRPORT
(5000 FT)

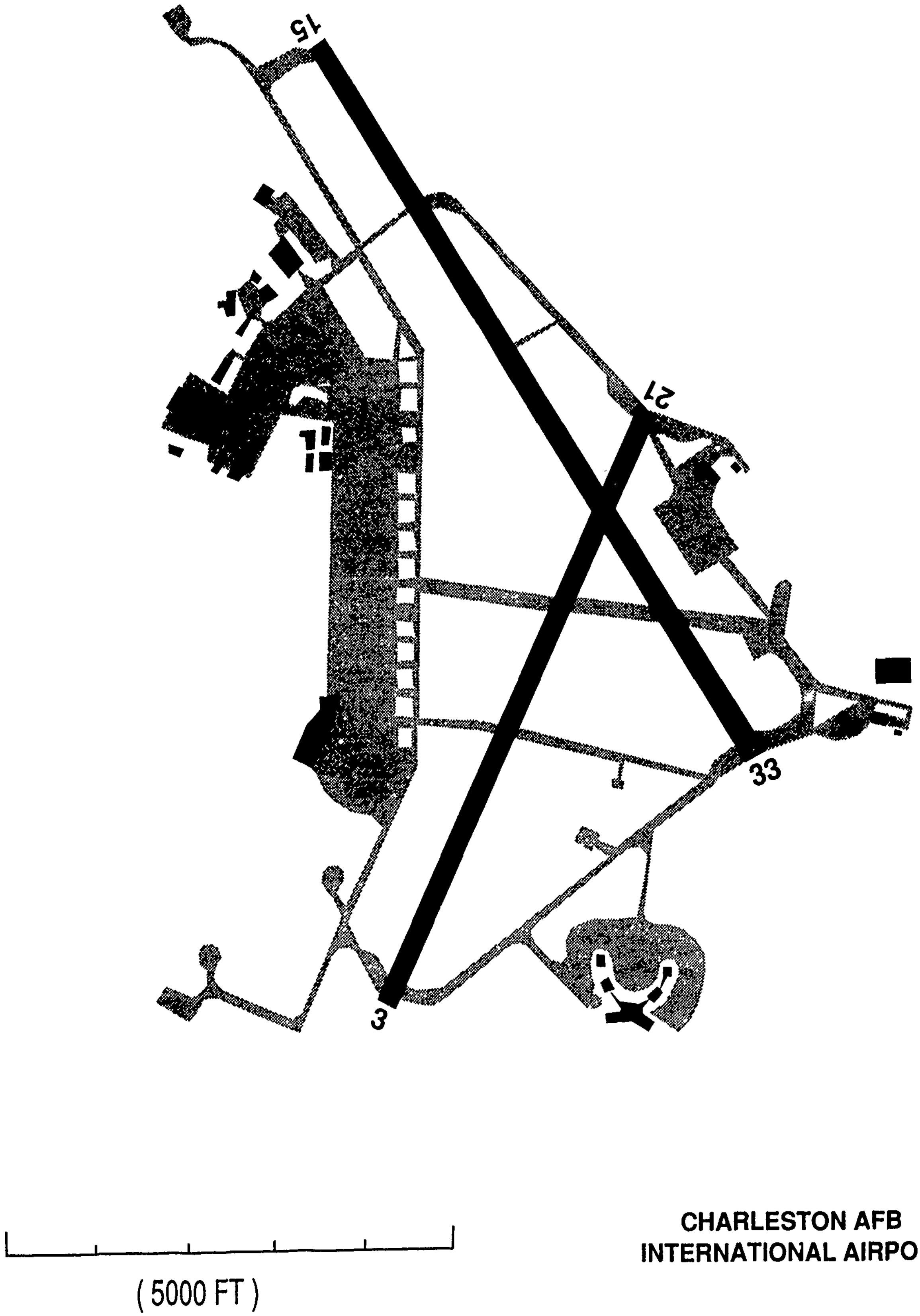


BRADLEY
INTERNATIONAL AIRPORT
(WINDSOR LOCKS)

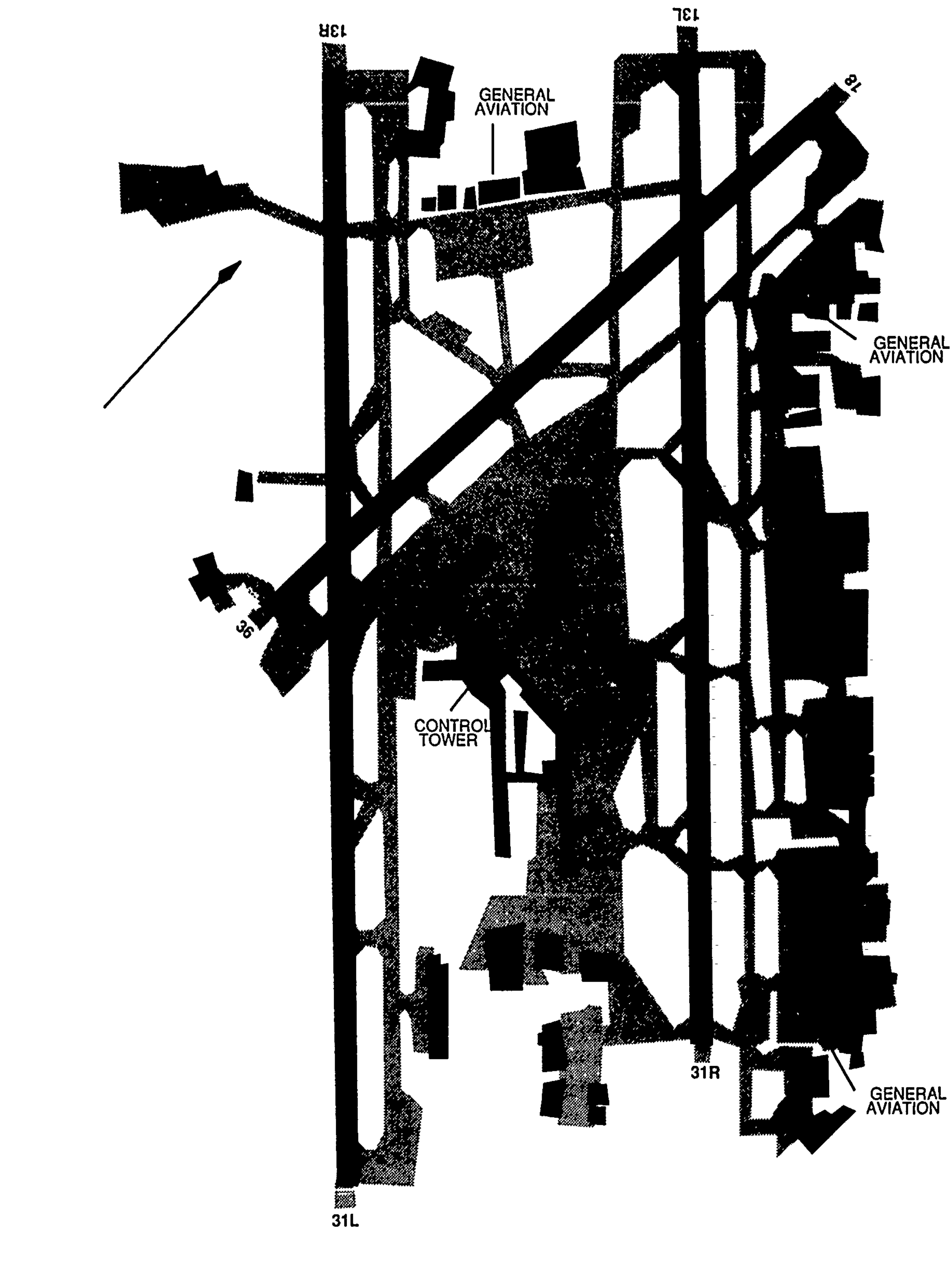


BURBANK-GLENDALE-PASADENA AIRPORT

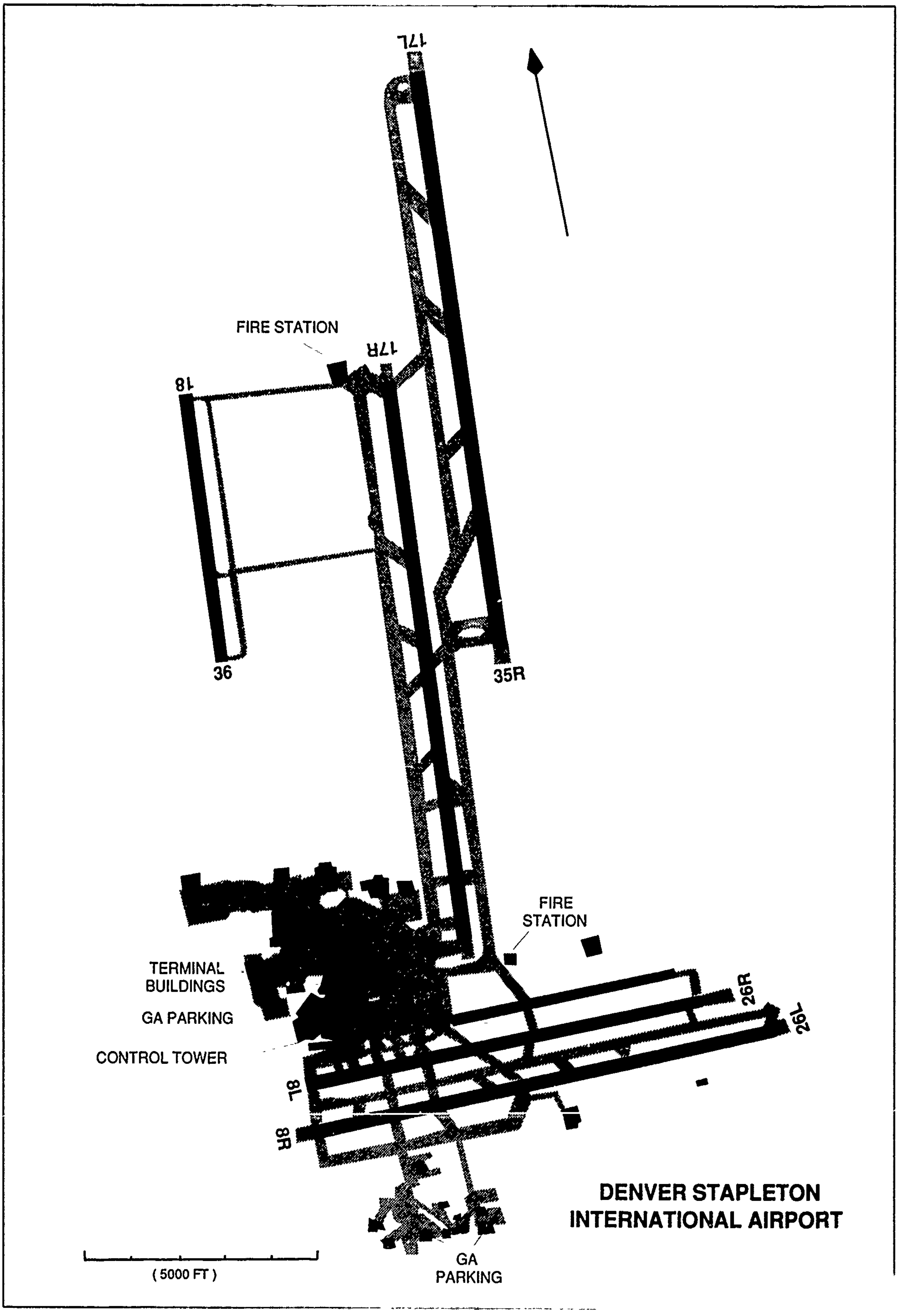
(5000 FT)

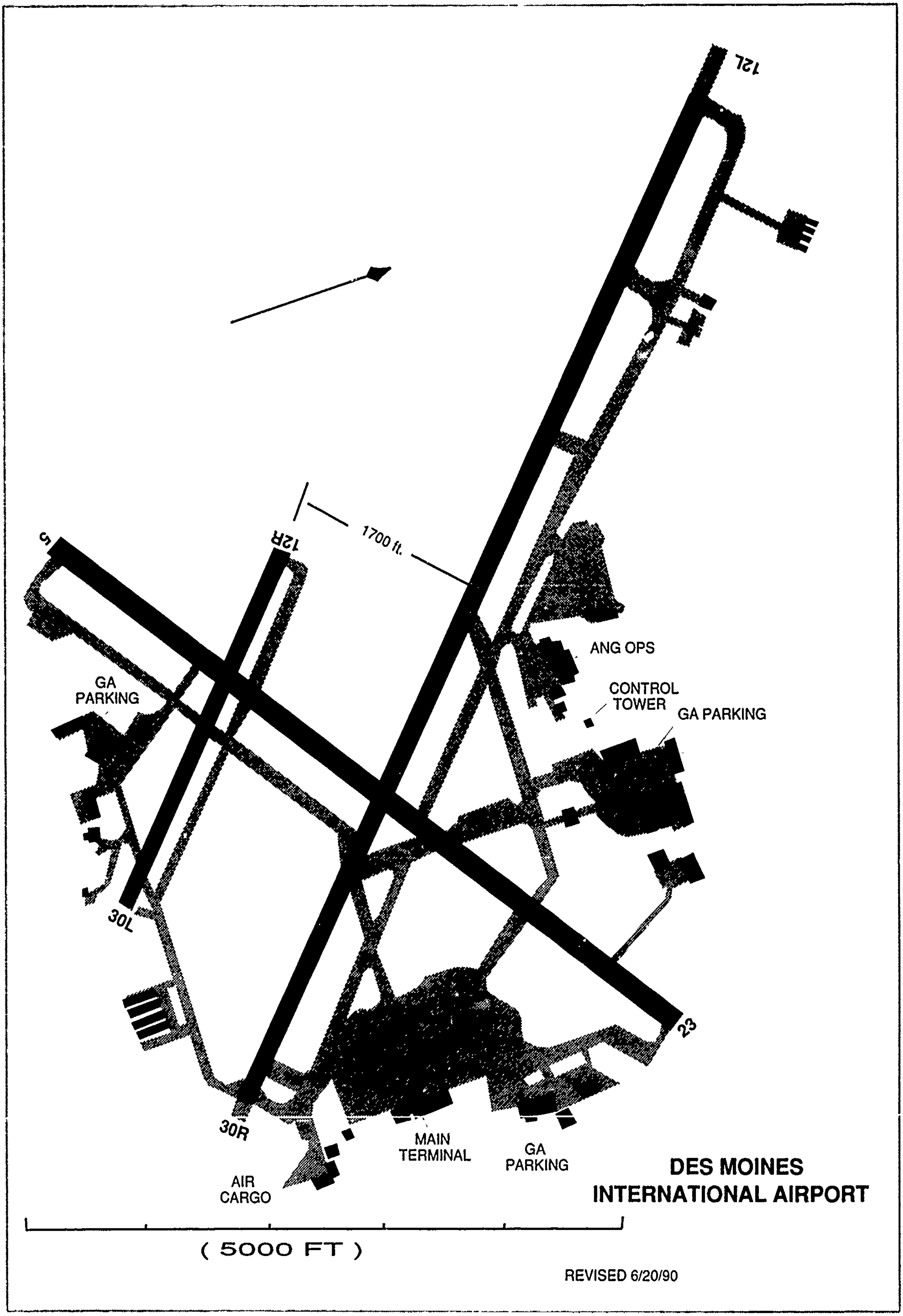


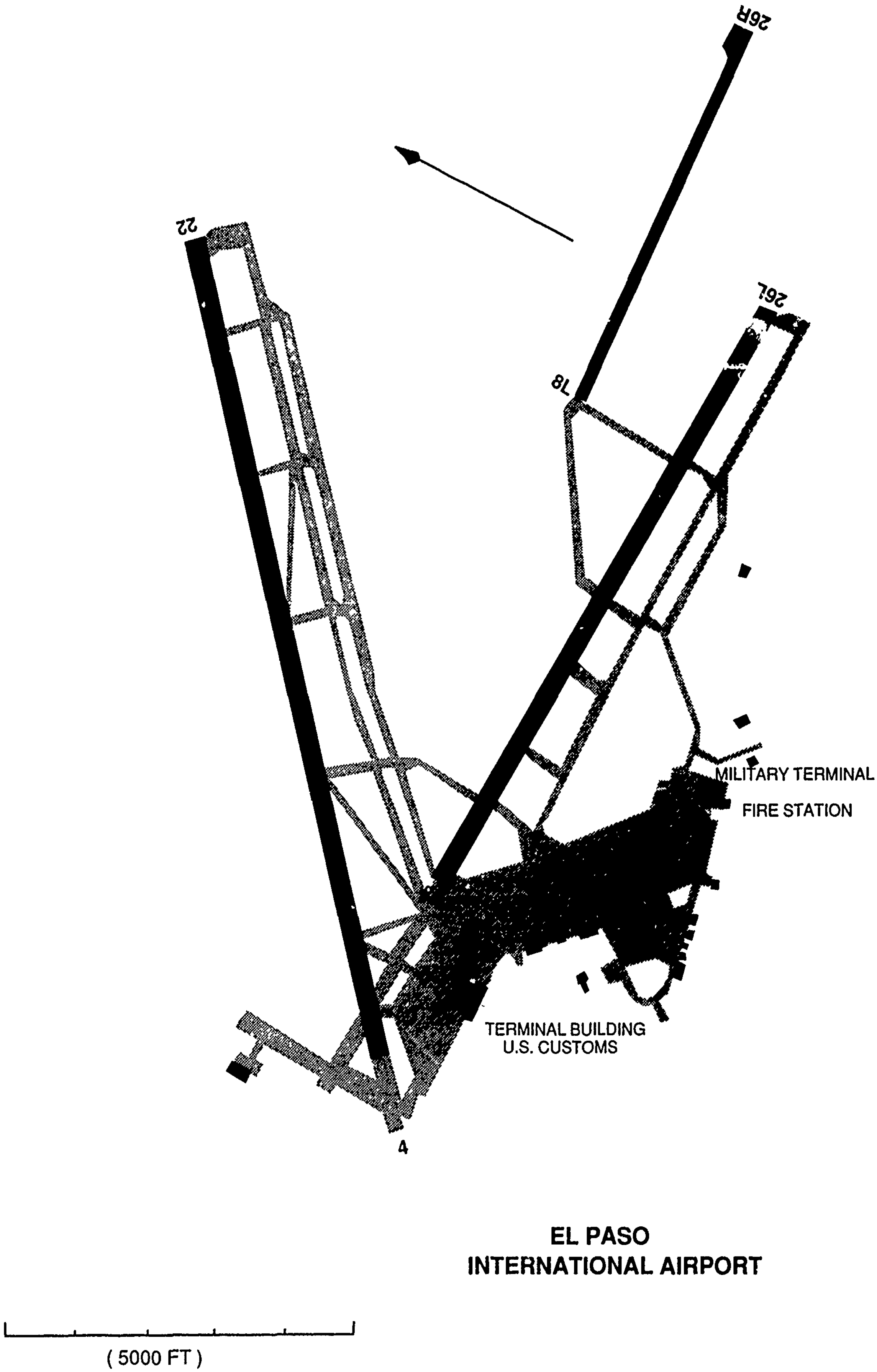
CHARLESTON AFB
INTERNATIONAL AIRPORT



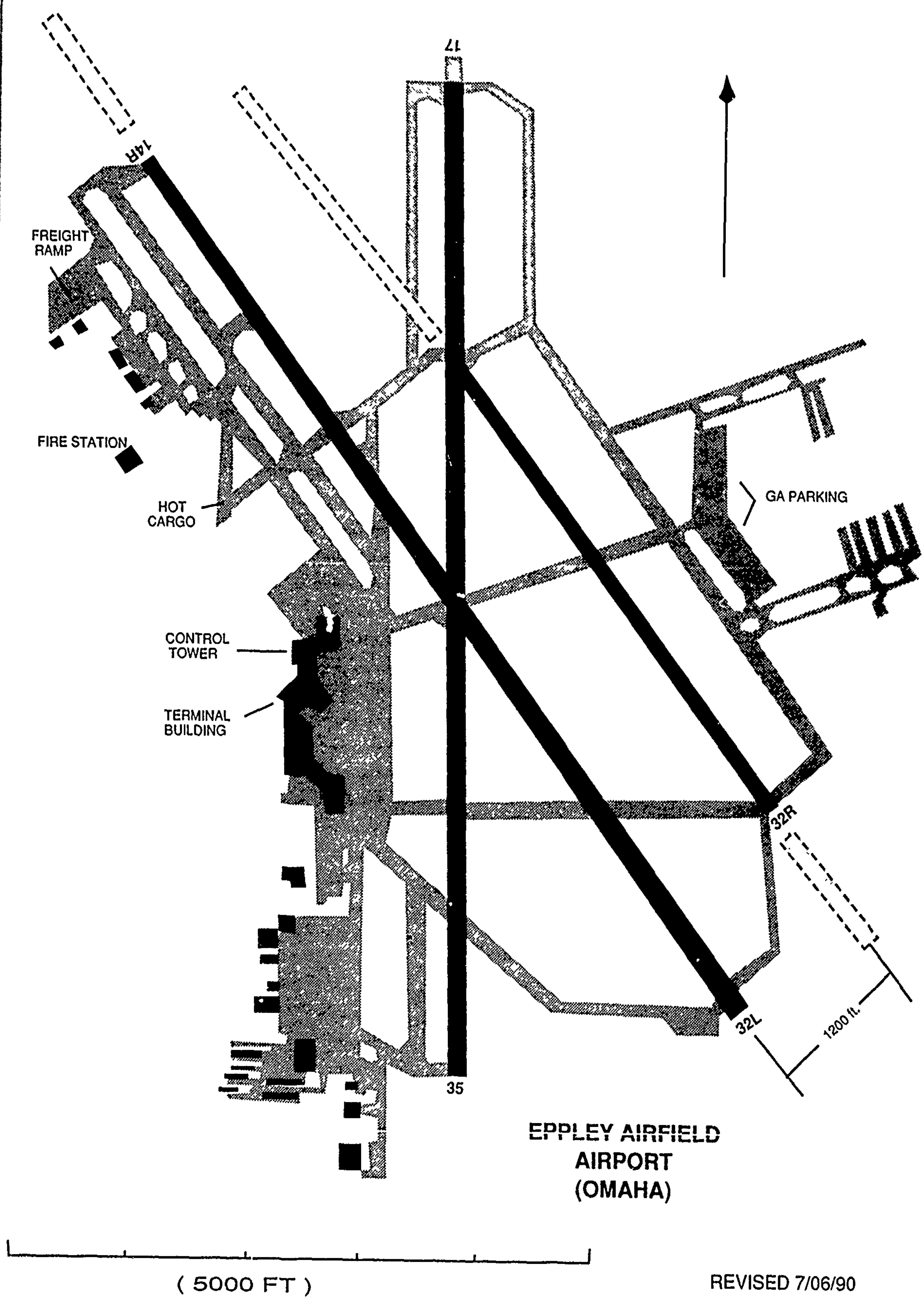
DALLAS
LOVE FIELD AIRPORT


17L
FIRE STATION
17R
18
36
35R
FIRE
STATION
TERMINAL
BUILDINGS
GA PARKING
CONTROL TOWER
26R
26L
8L
8R
DENVER STAPLETON
INTERNATIONAL AIRPORT
(5000 FT)
GA
PARKING


12L
12R
1700 ft.
5
30L
ANG OPS
CONTROL
TOWER
GA PARKING
GA
PARKING
23
30R
MAIN
TERMINAL
GA
PARKING
AIR
CARGO
DES MOINES
INTERNATIONAL AIRPORT
(5000 FT)
REVISED 6/20/90

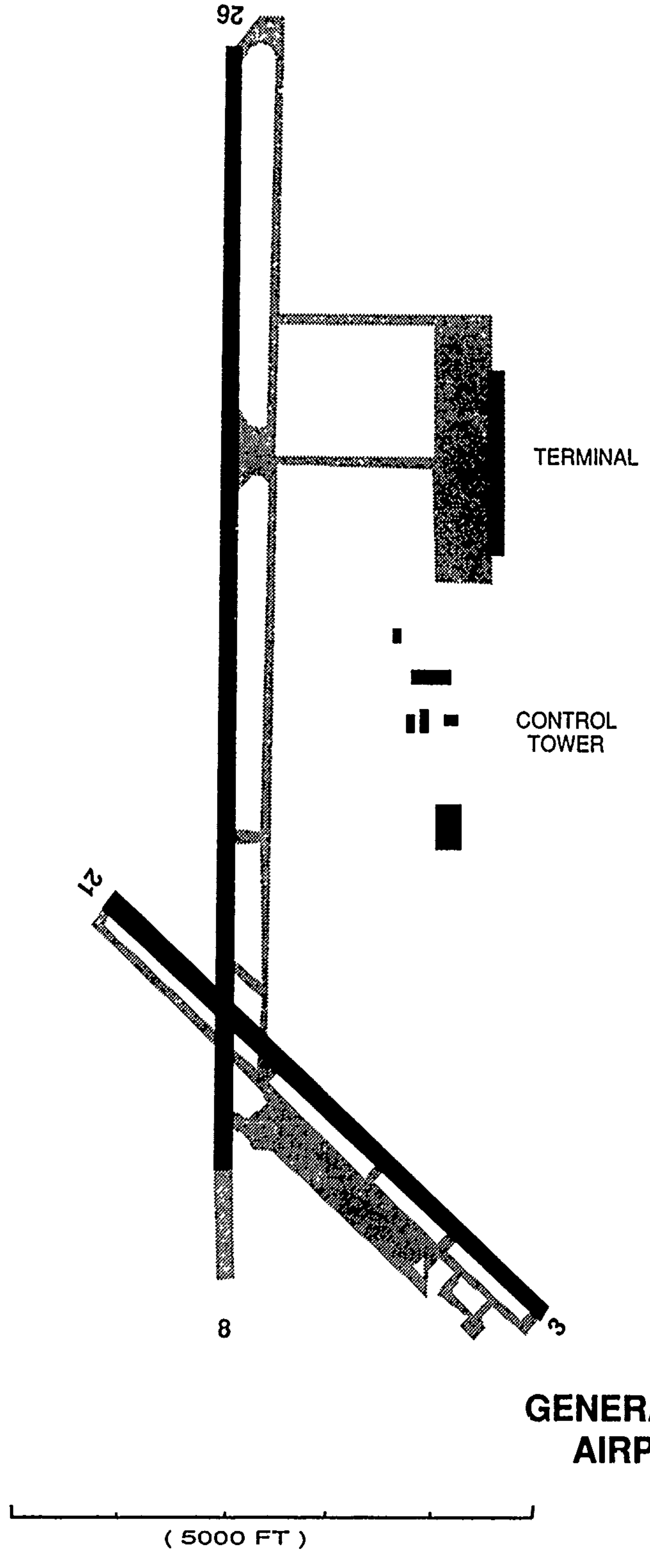


EL PASO INTERNATIONAL AIRPORT

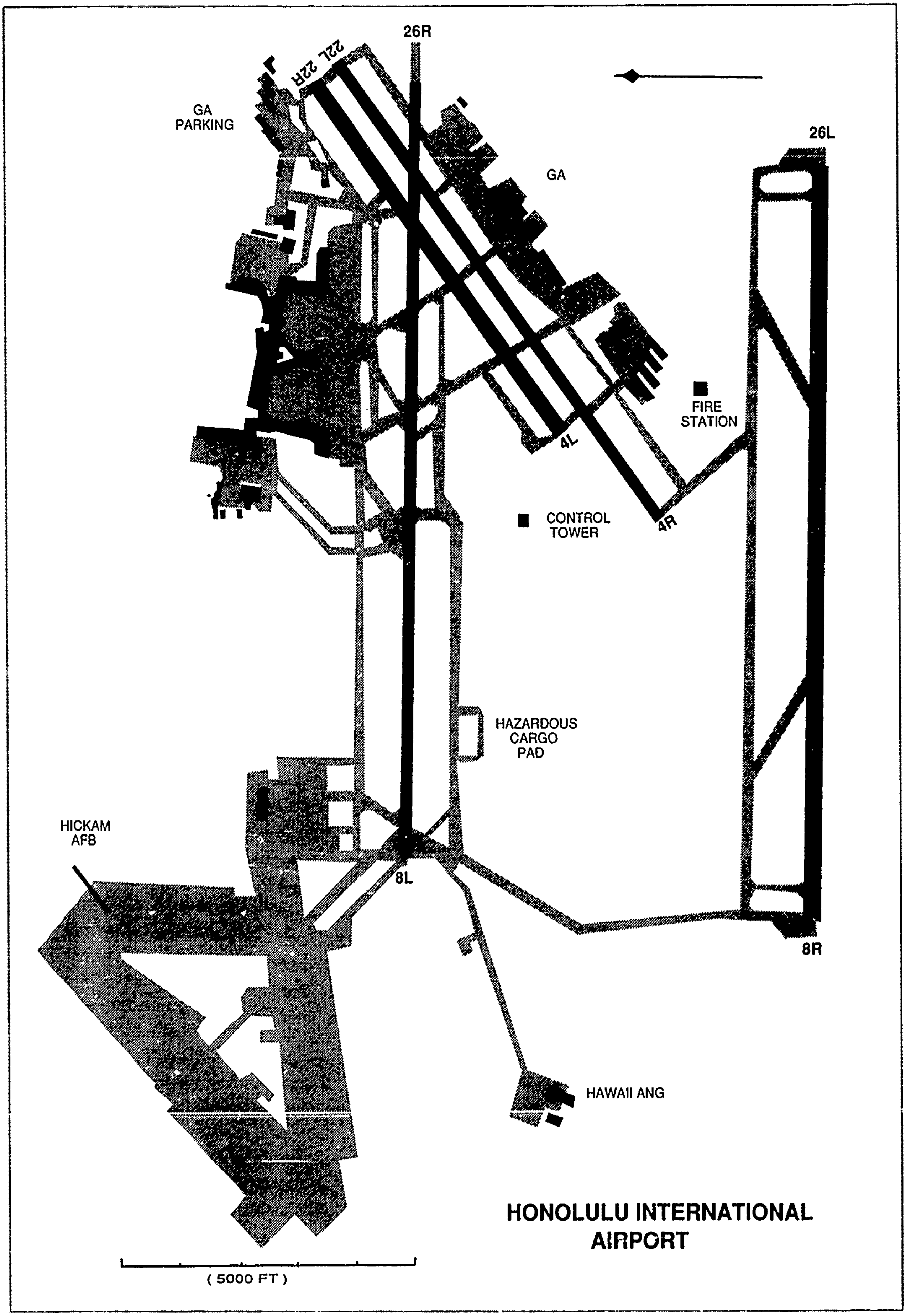


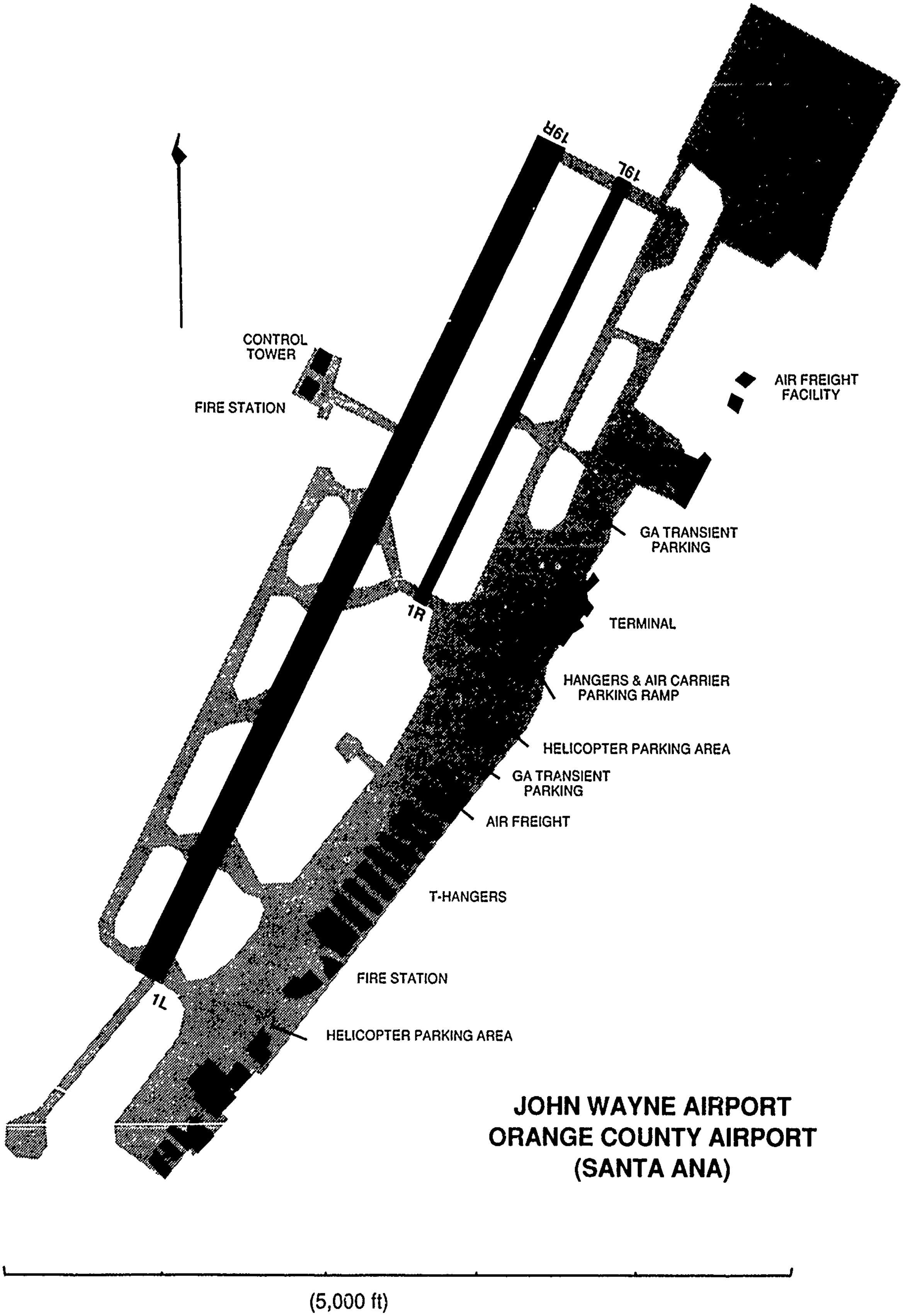
EPPLEY AIRFIELD AIRPORT (OMAHA)

REVISED 7/06/90

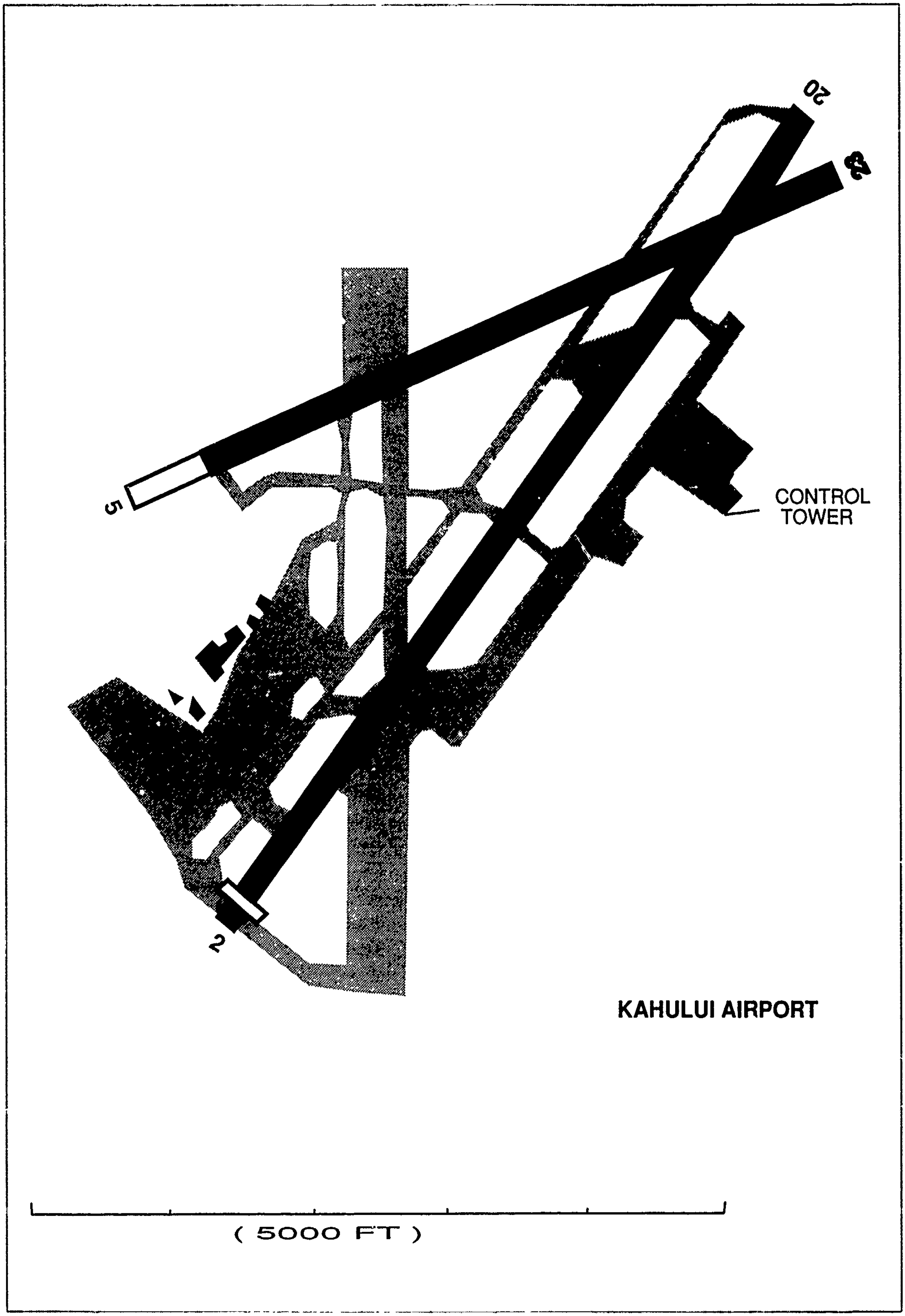


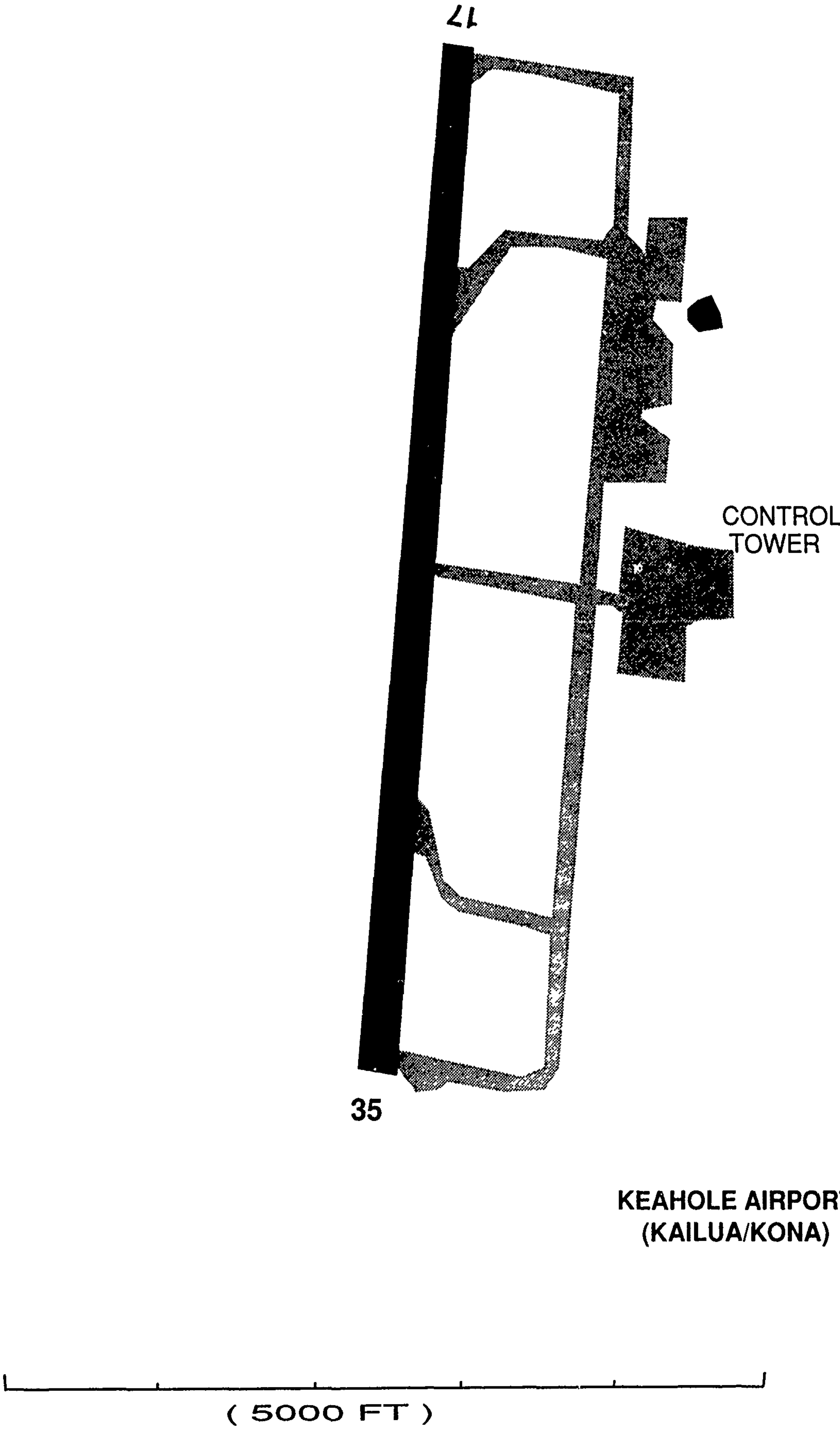
GENERAL LYMAN FIELD
AIRPORT (HILO)


26R
22L 22R
GA
PARKING
GA
26L
FIRE
STATION
4L
CONTROL
TOWER
4R
HAZARDOUS
CARGO
PAD
HICKAM
AFB
8L
8R
HAWAII ANG
HONOLULU INTERNATIONAL
AIRPORT
(5000 FT)

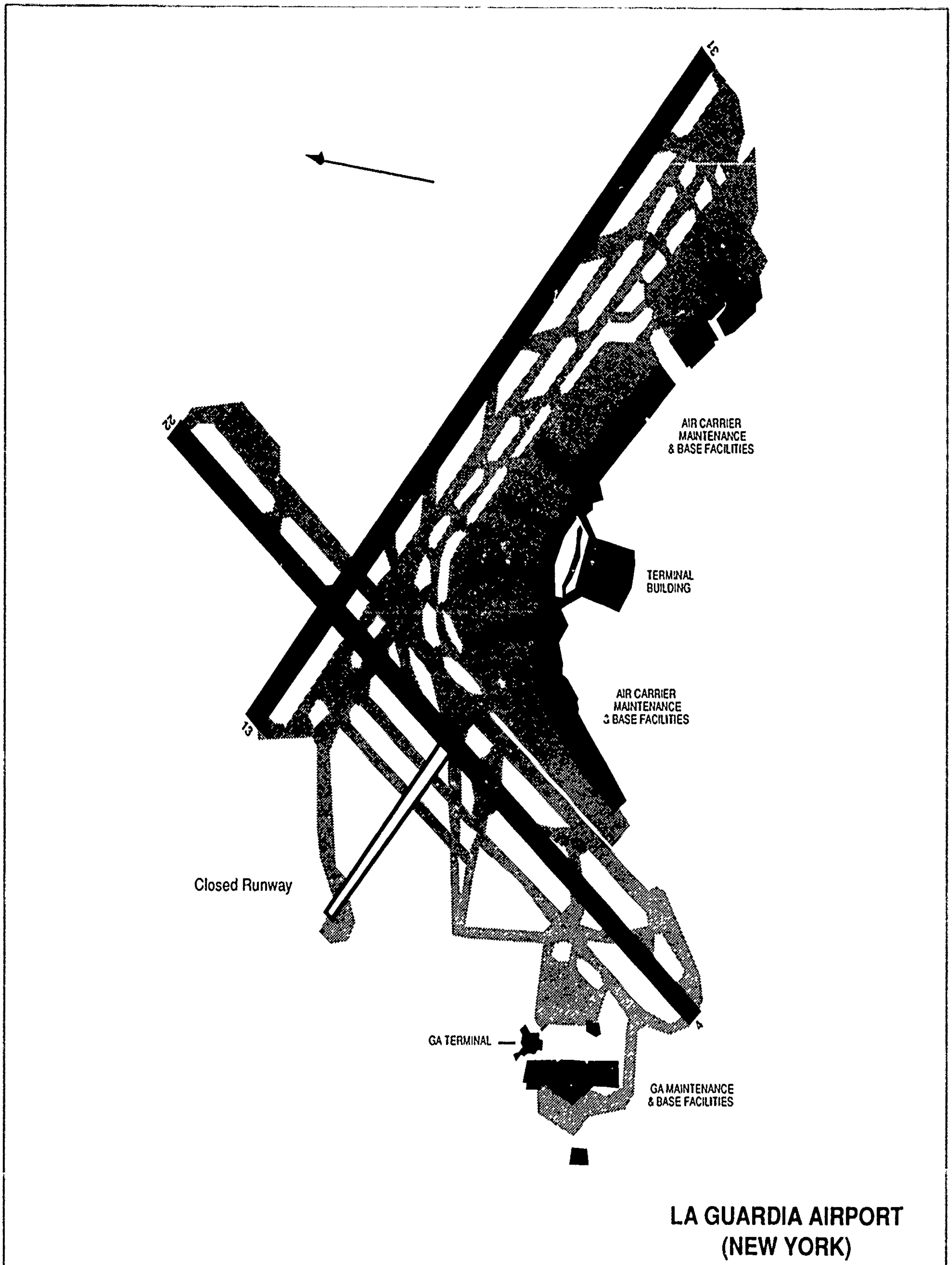


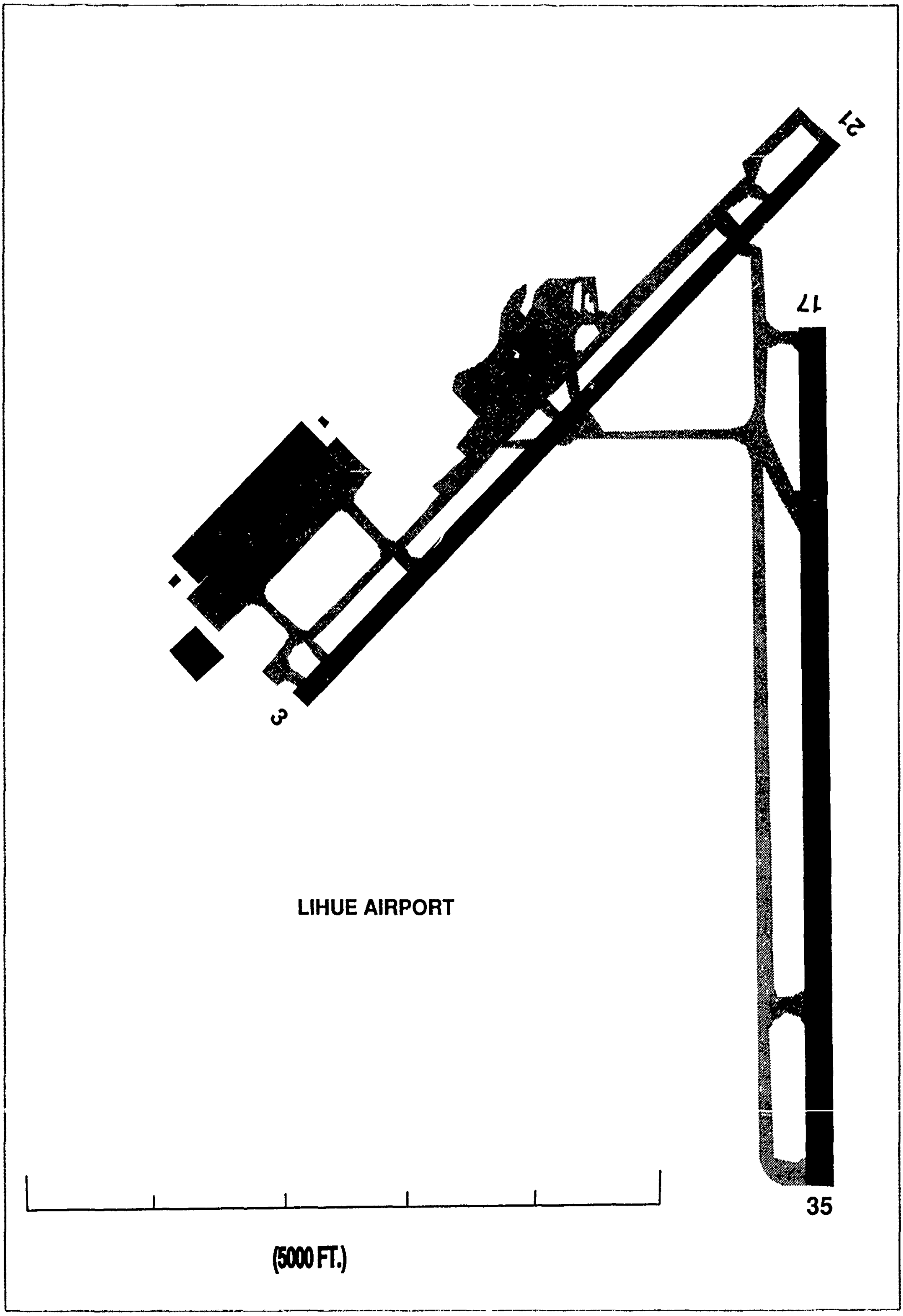
JOHN WAYNE AIRPORT
ORANGE COUNTY AIRPORT
(SANTA ANA)

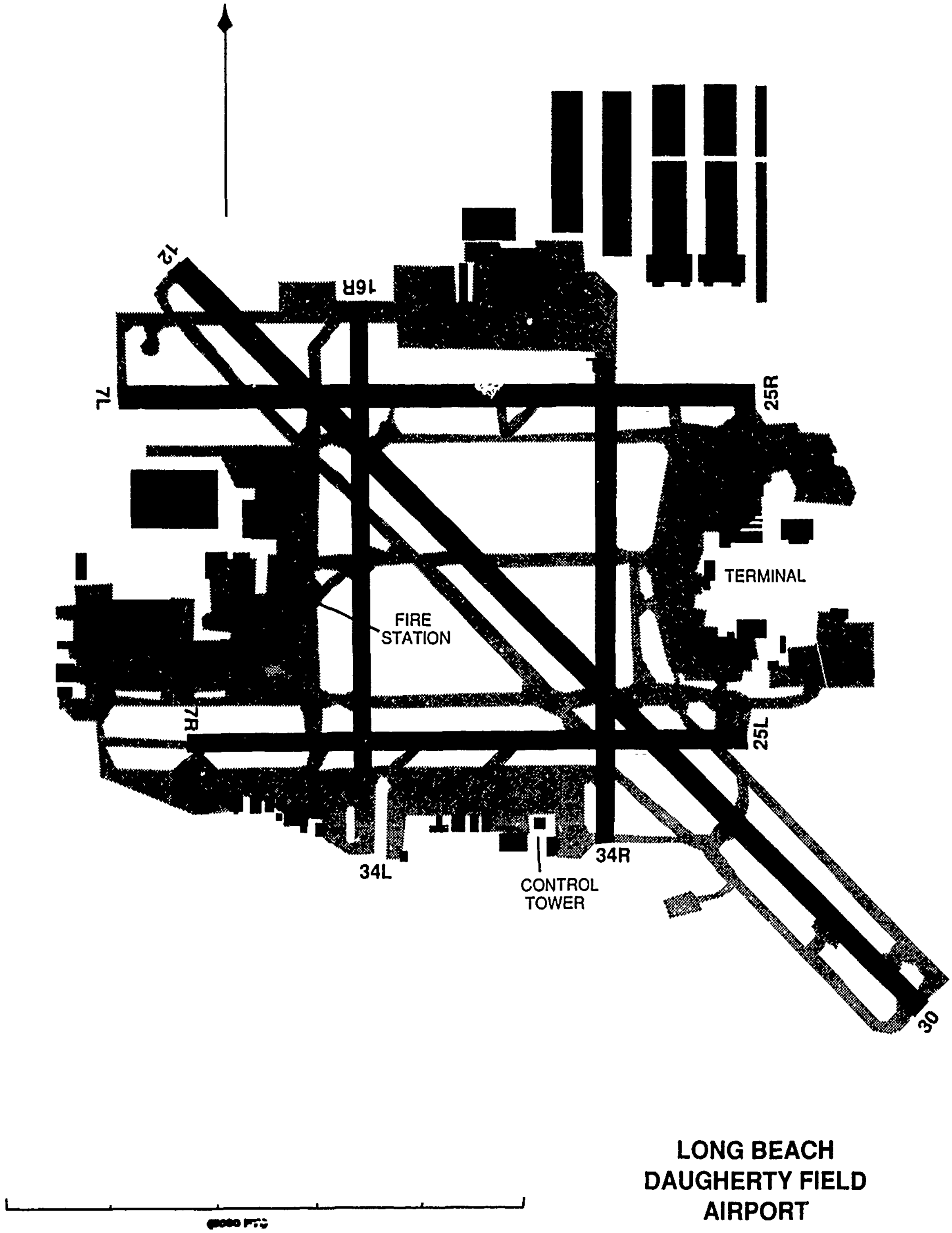

20
23
5
2
CONTROL
TOWER
KAHULUI AIRPORT
(5000 FT)



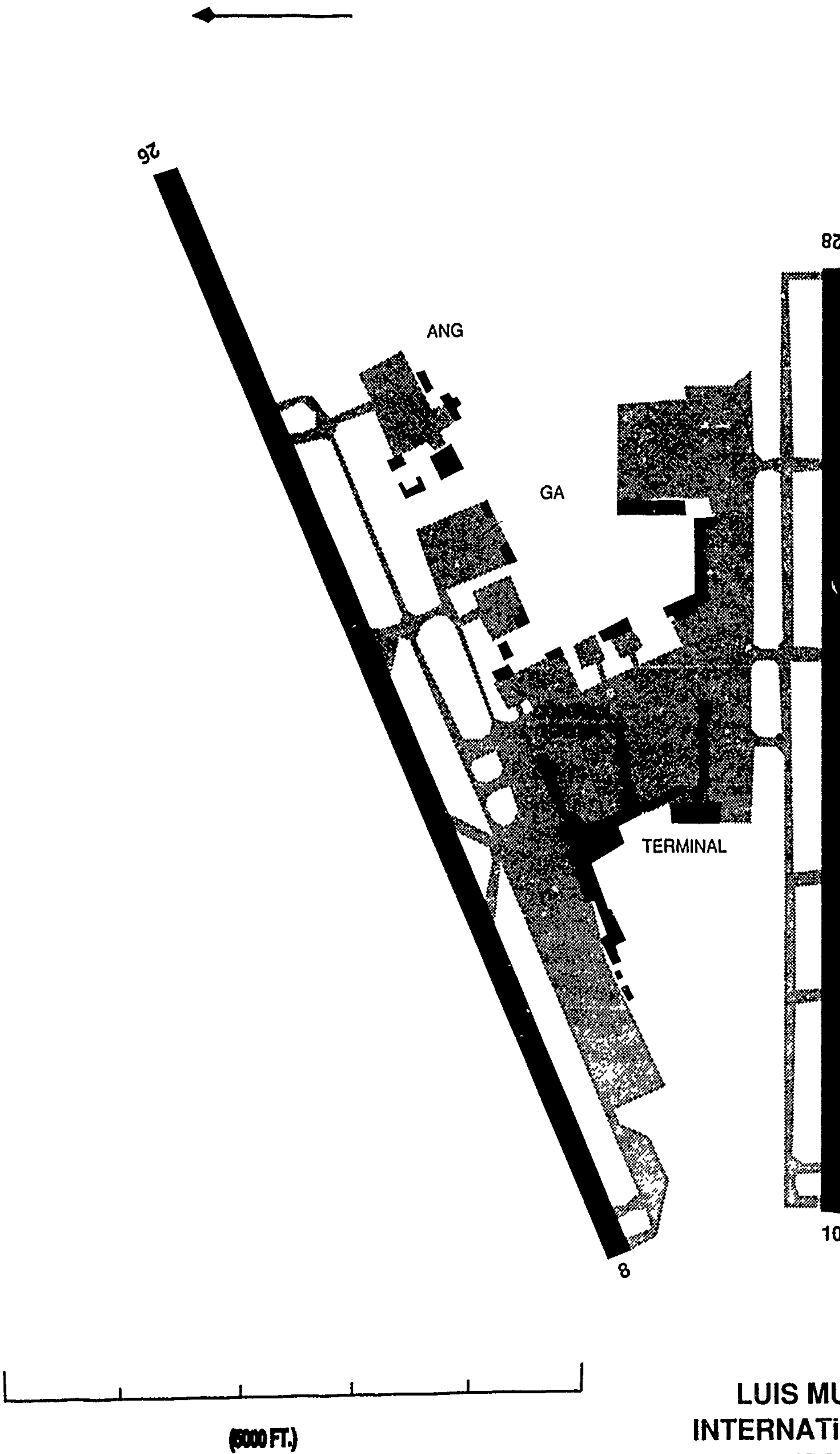
KEAHOLE AIRPORT
(KAILUA/KONA)


31
22
13
4
AIR CARRIER
MAINTENANCE
& BASE FACILITIES
TERMINAL
BUILDING
AIR CARRIER
MAINTENANCE
& BASE FACILITIES
Closed Runway
GA TERMINAL
GA MAINTENANCE
& BASE FACILITIES
LA GUARDIA AIRPORT
(NEW YORK)
(5000 FT)

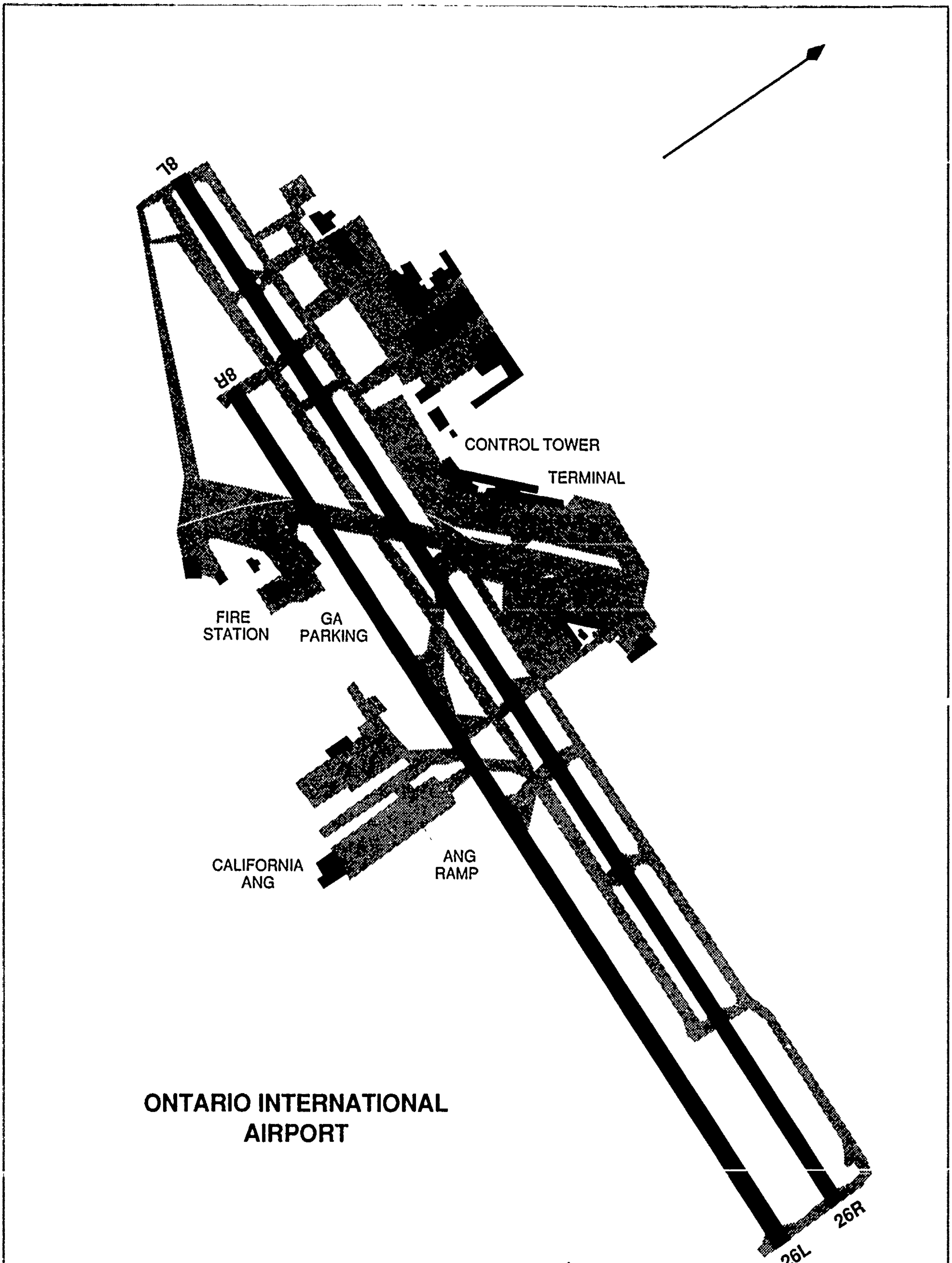

21
17
3
35
LIHUE AIRPORT
(5000 FT.)

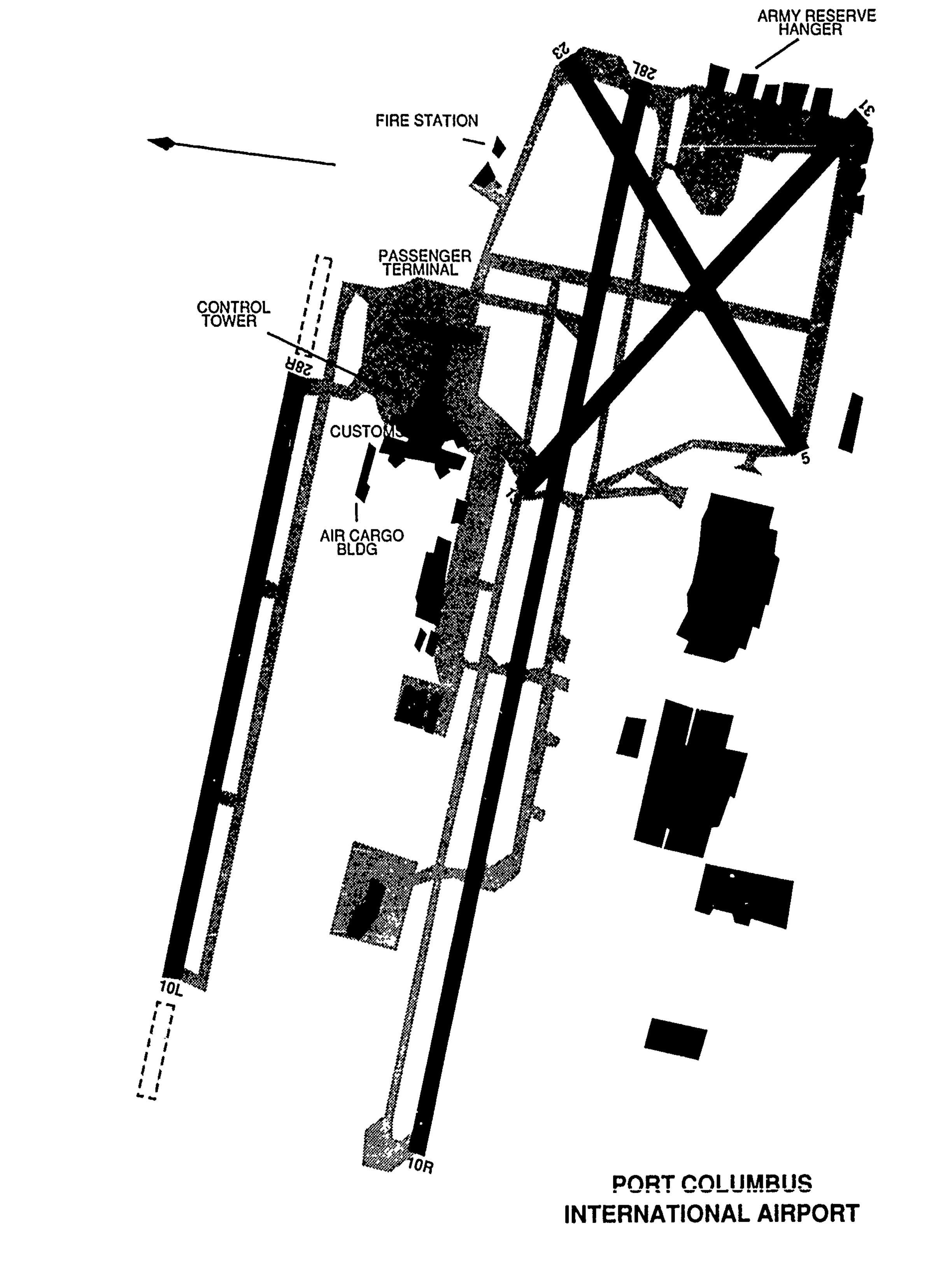


LONG BEACH
DAUGHERTY FIELD
AIRPORT



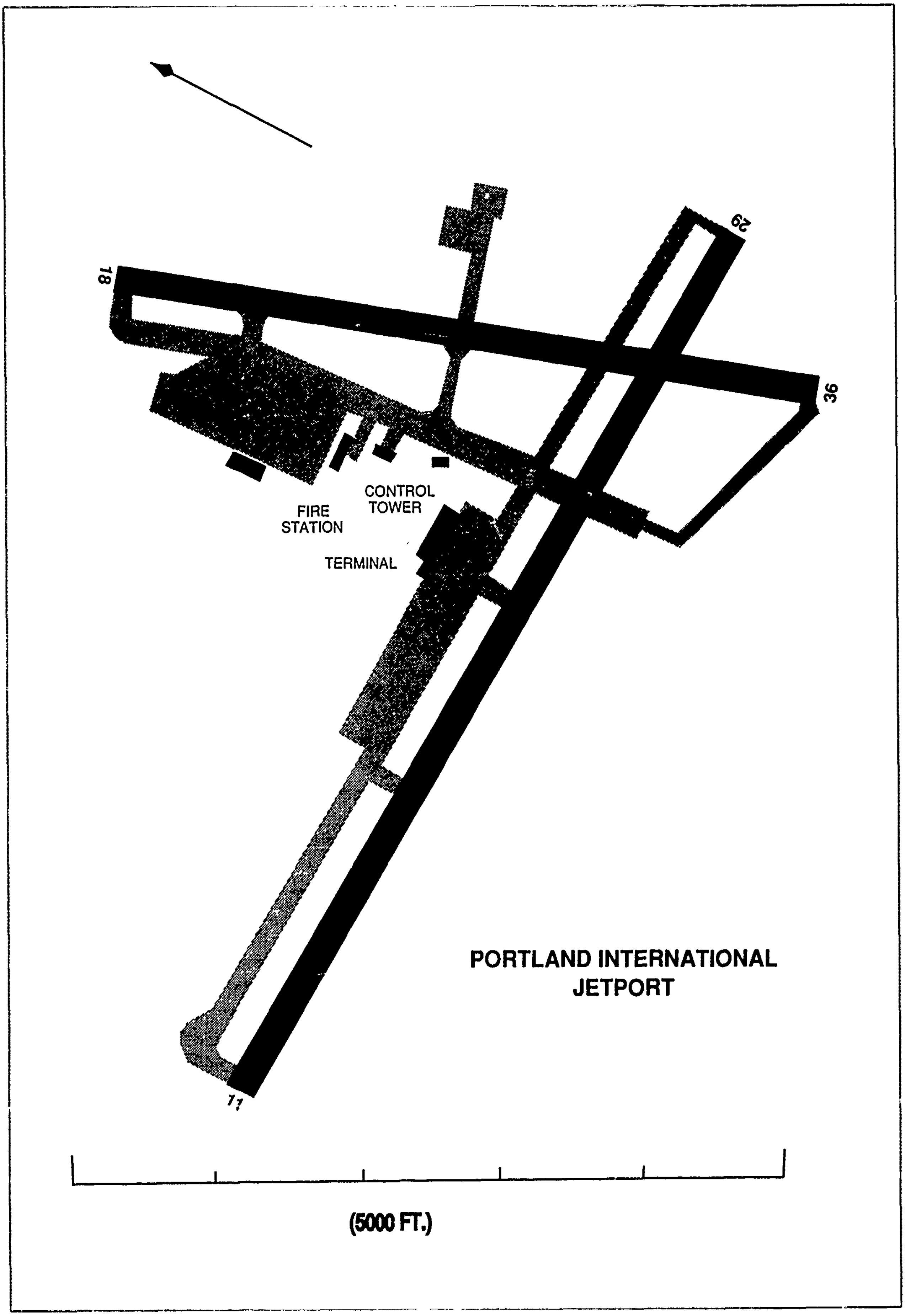
LUIS MUNOZ MARIN
INTERNATIONAL AIRPORT
(SAN JUAN)

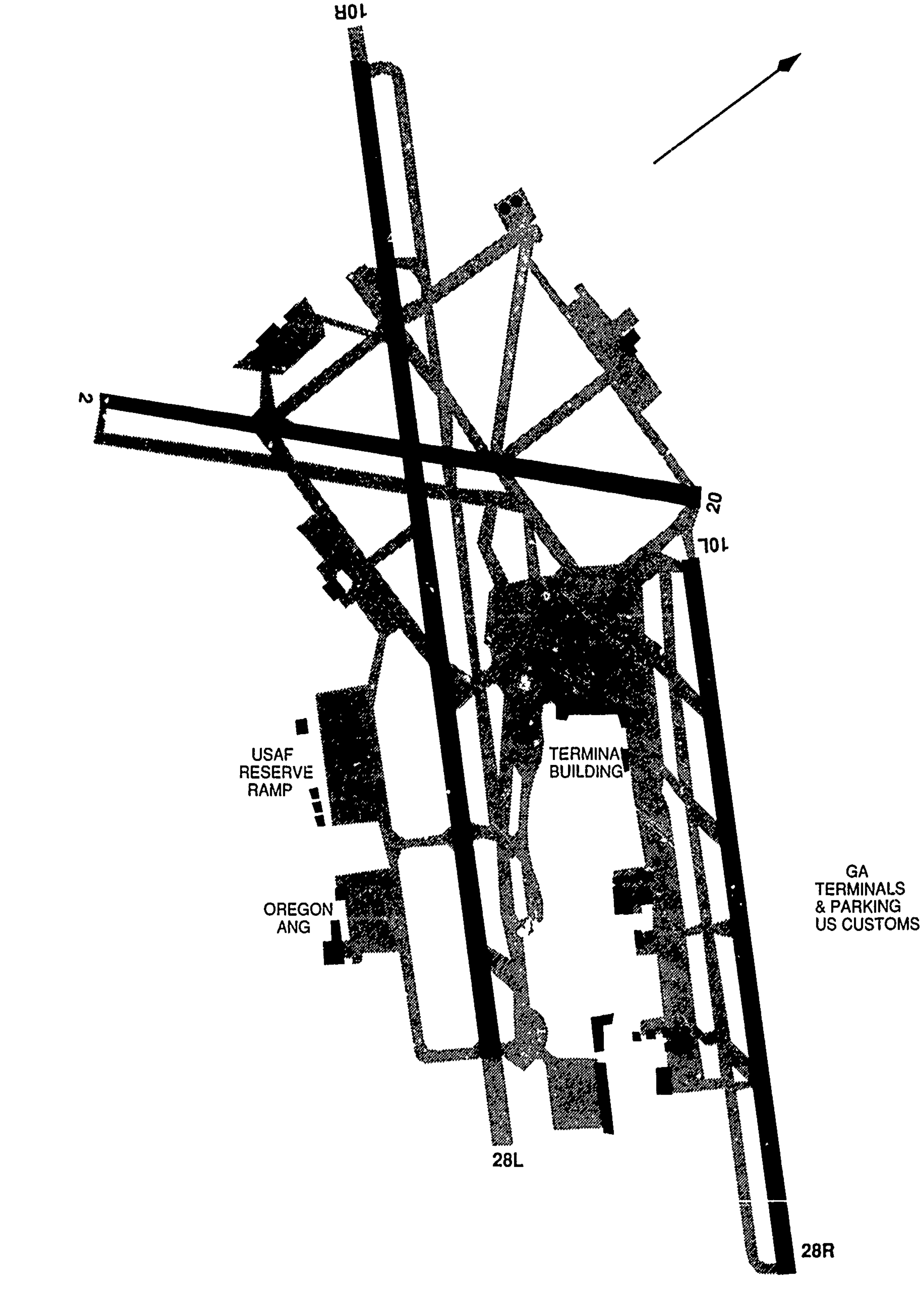

8L
8R
CONTROL TOWER
TERMINAL
FIRE
STATION
GA
PARKING
CALIFORNIA
ANG
ANG
RAMP
26L
26R
ONTARIO INTERNATIONAL
AIRPORT
(5000 FT.)



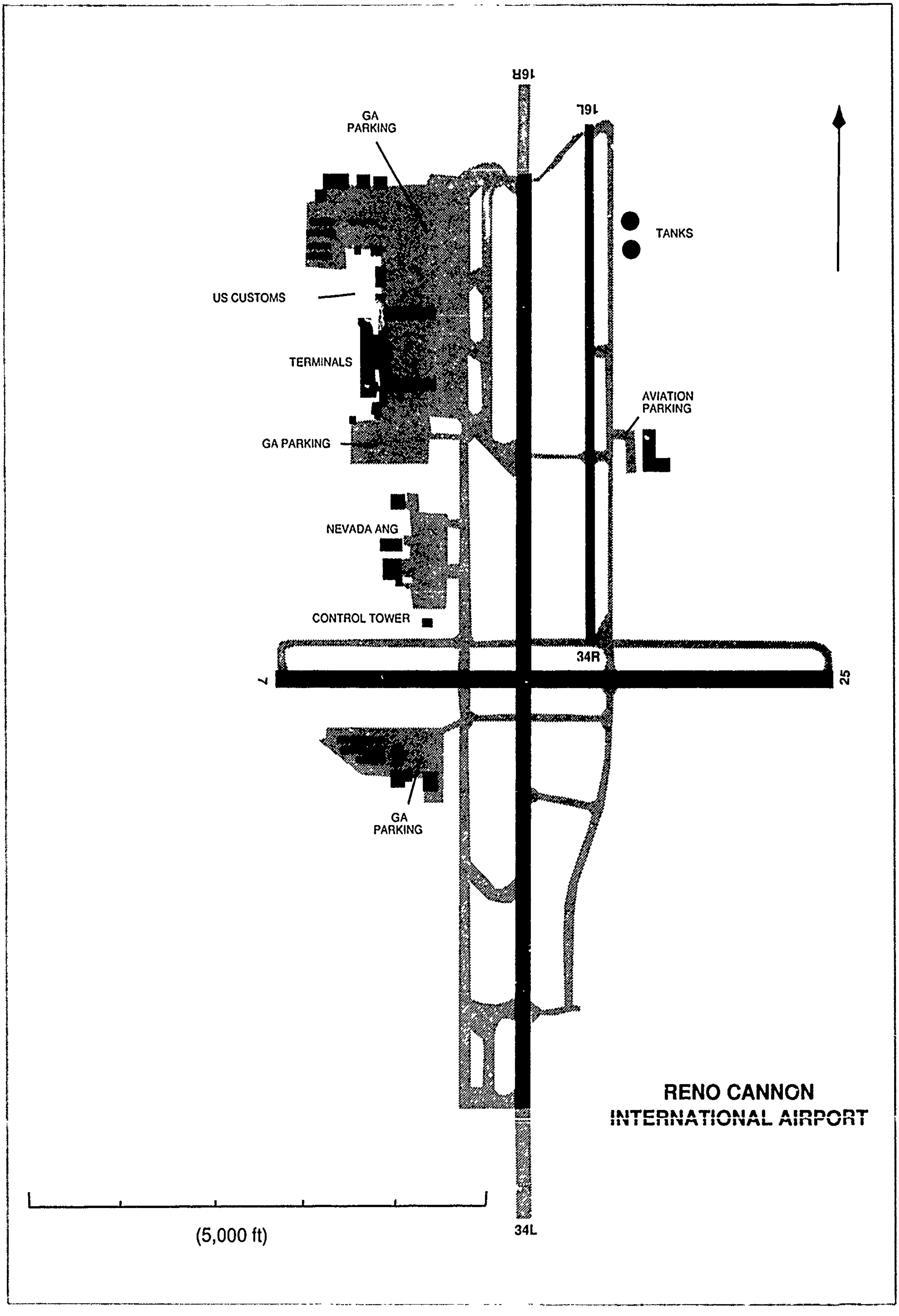
PORT COLUMBUS INTERNATIONAL AIRPORT

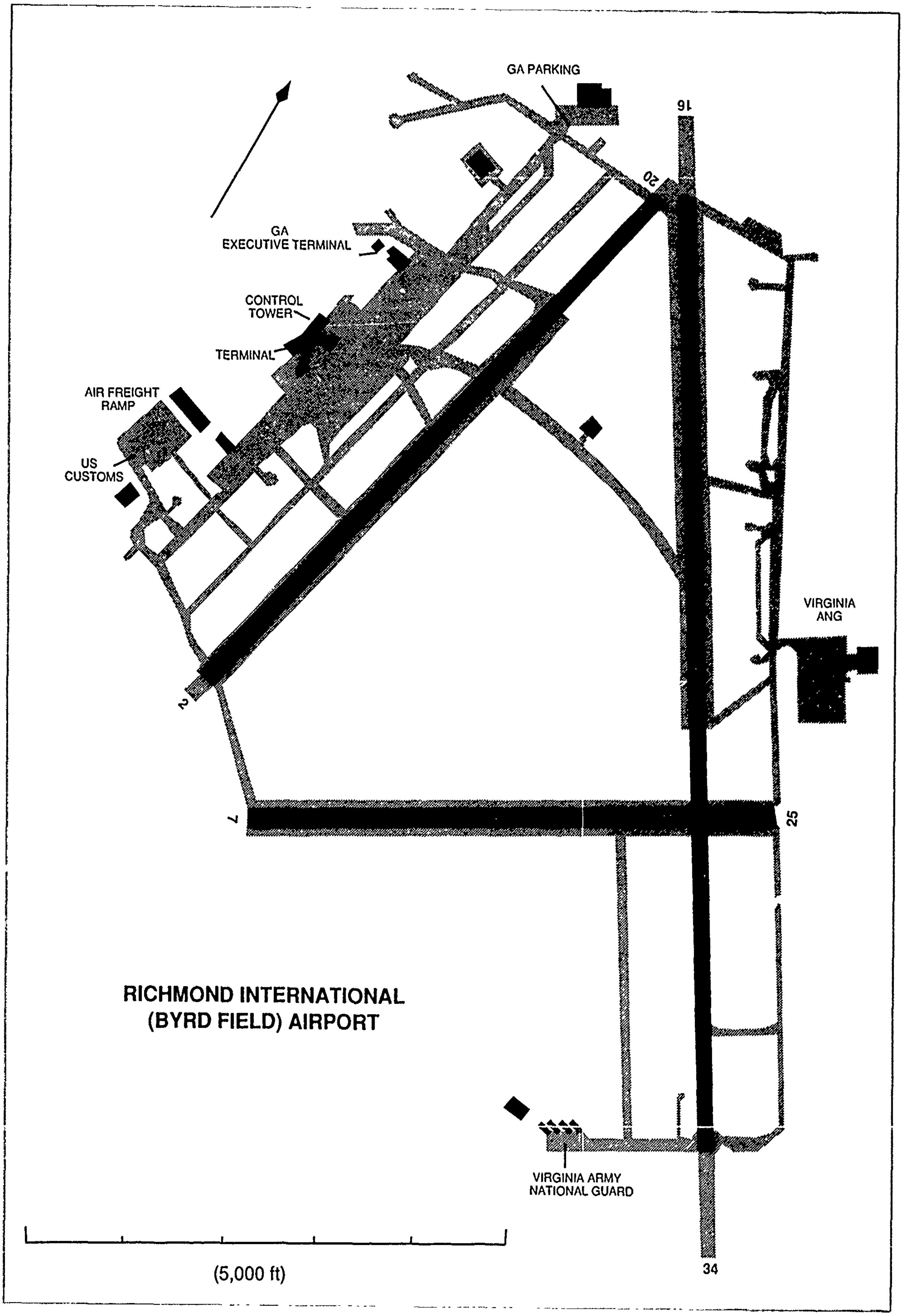
Revised 7/06/90

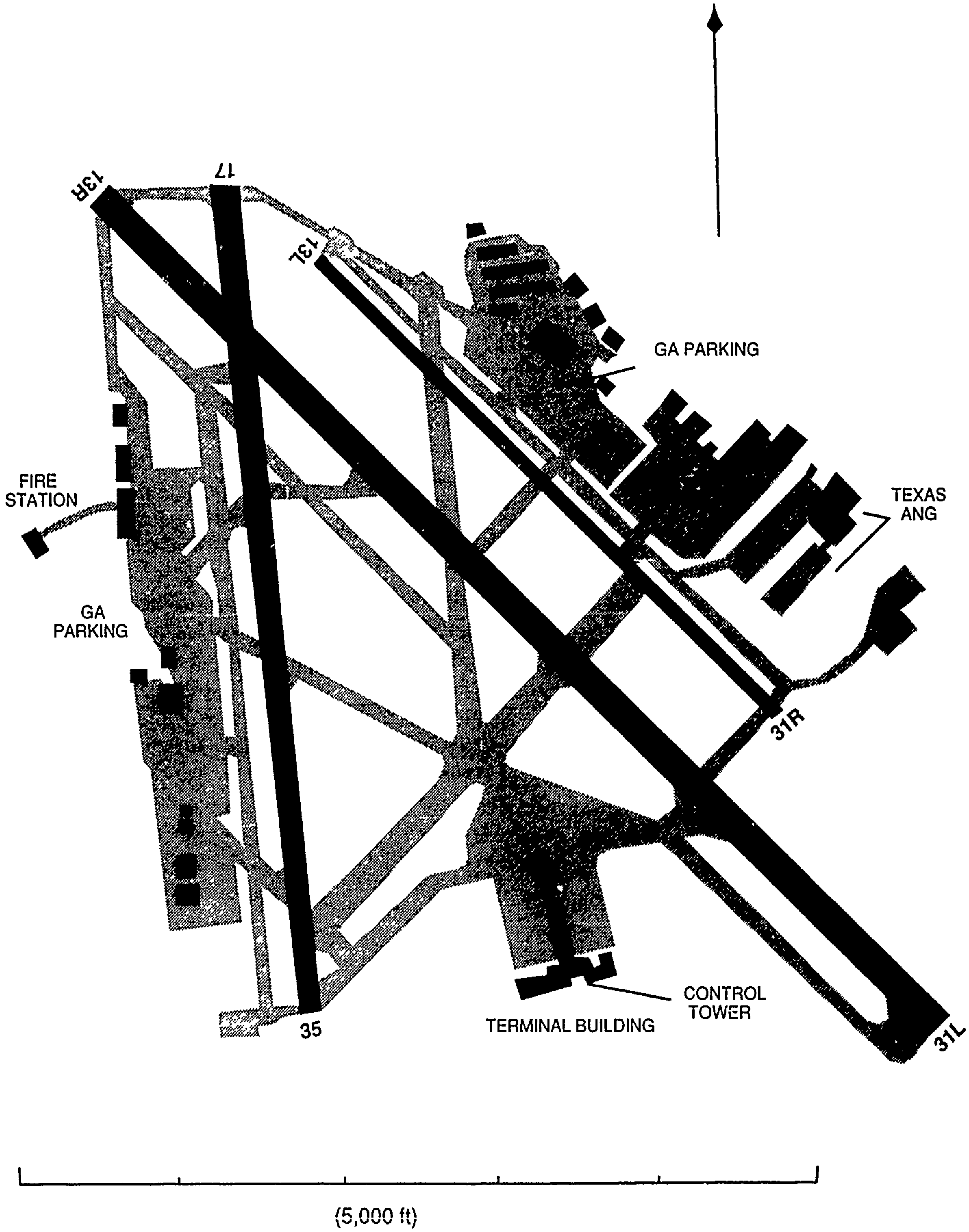

29
18
36
CONTROL
TOWER
FIRE
STATION
TERMINAL
11
PORTLAND INTERNATIONAL
JETPORT
(5000 FT.)



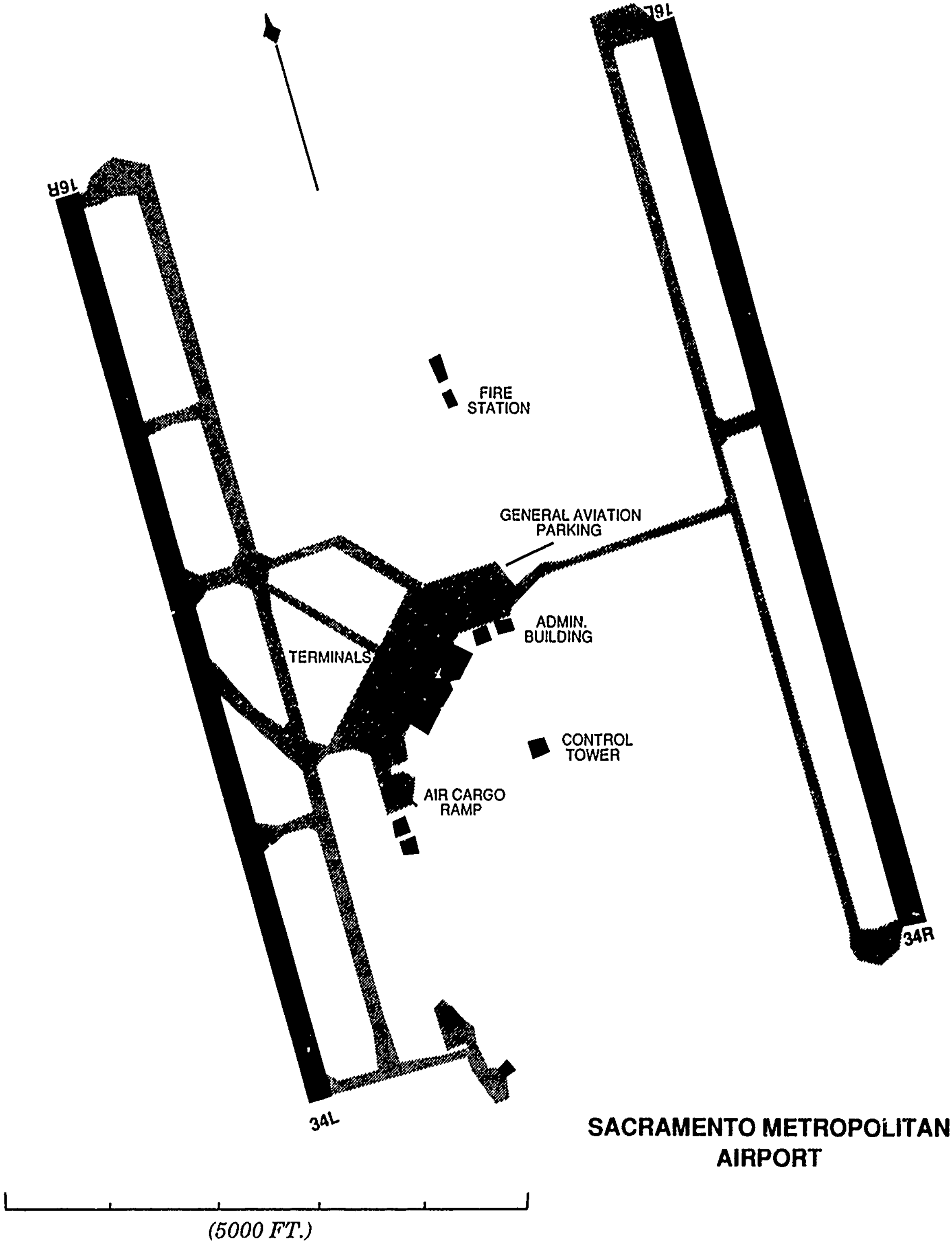
PORTLAND (OR) INTERNATIONAL AIRPORT


16R
16L
GA
PARKING
TANKS
US CUSTOMS
TERMINALS
AVIATION
PARKING
GA PARKING
NEVADA ANG
CONTROL TOWER
34R
7
25
GA
PARKING
RENO CANNON
INTERNATIONAL AIRPORT
(5,000 ft)
34L

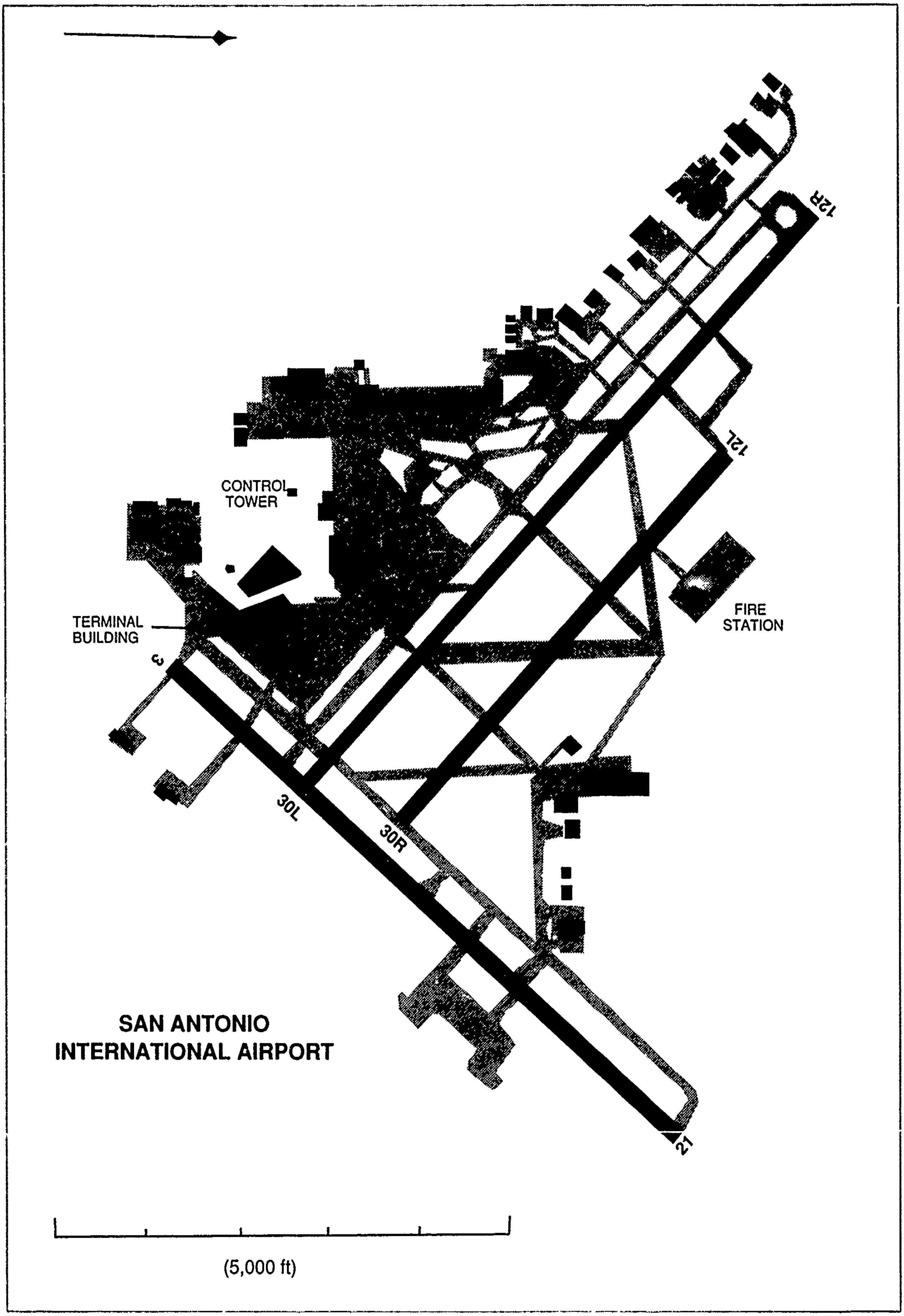

GA PARKING
16
20
GA
EXECUTIVE TERMINAL
CONTROL
TOWER
TERMINAL
AIR FREIGHT
RAMP
US
CUSTOMS
2
VIRGINIA
ANG
7
25
RICHMOND INTERNATIONAL
(BYRD FIELD) AIRPORT
VIRGINIA ARMY
NATIONAL GUARD
(5,000 ft)
34



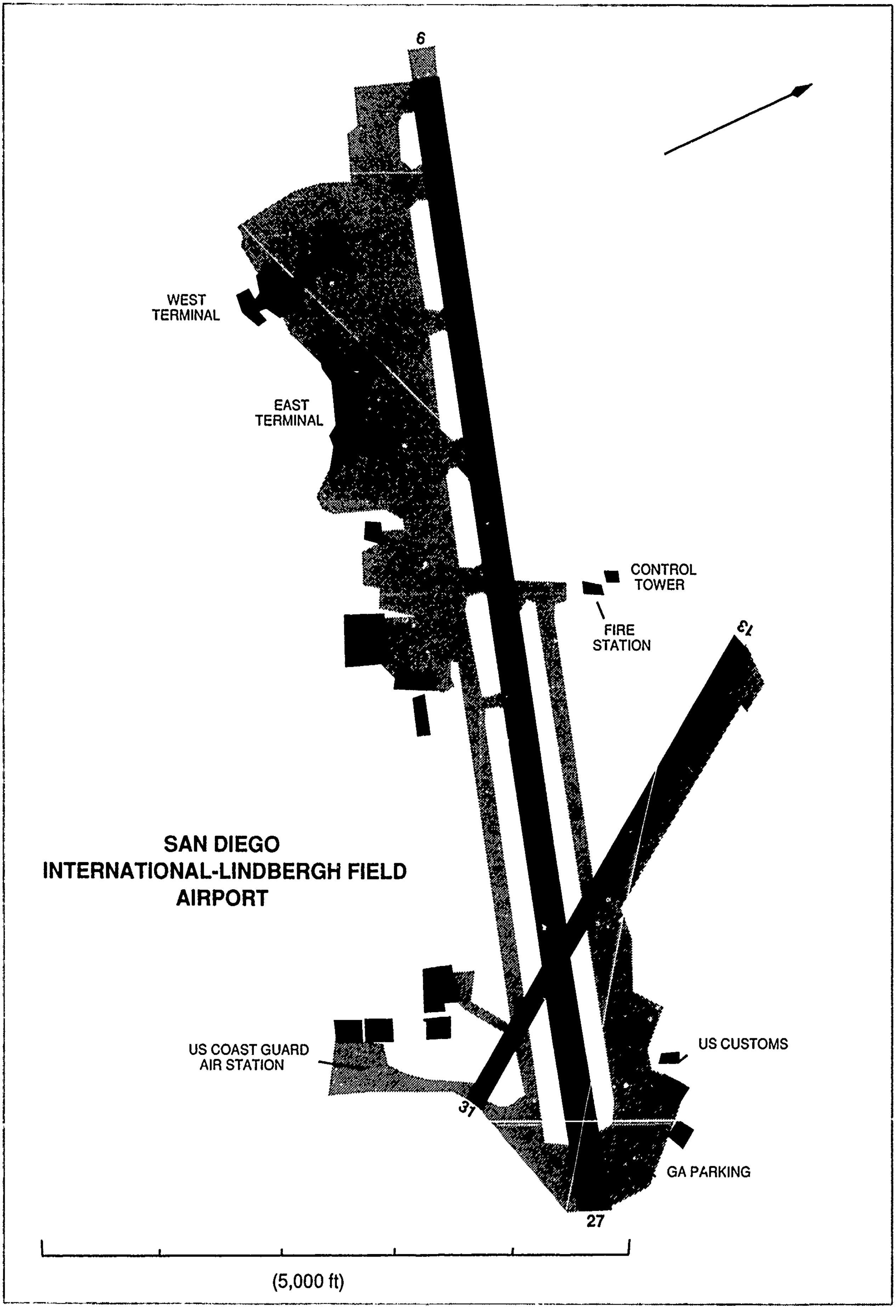
ROBERT MUELLER MUNICIPAL AIRPORT (AUSTIN)

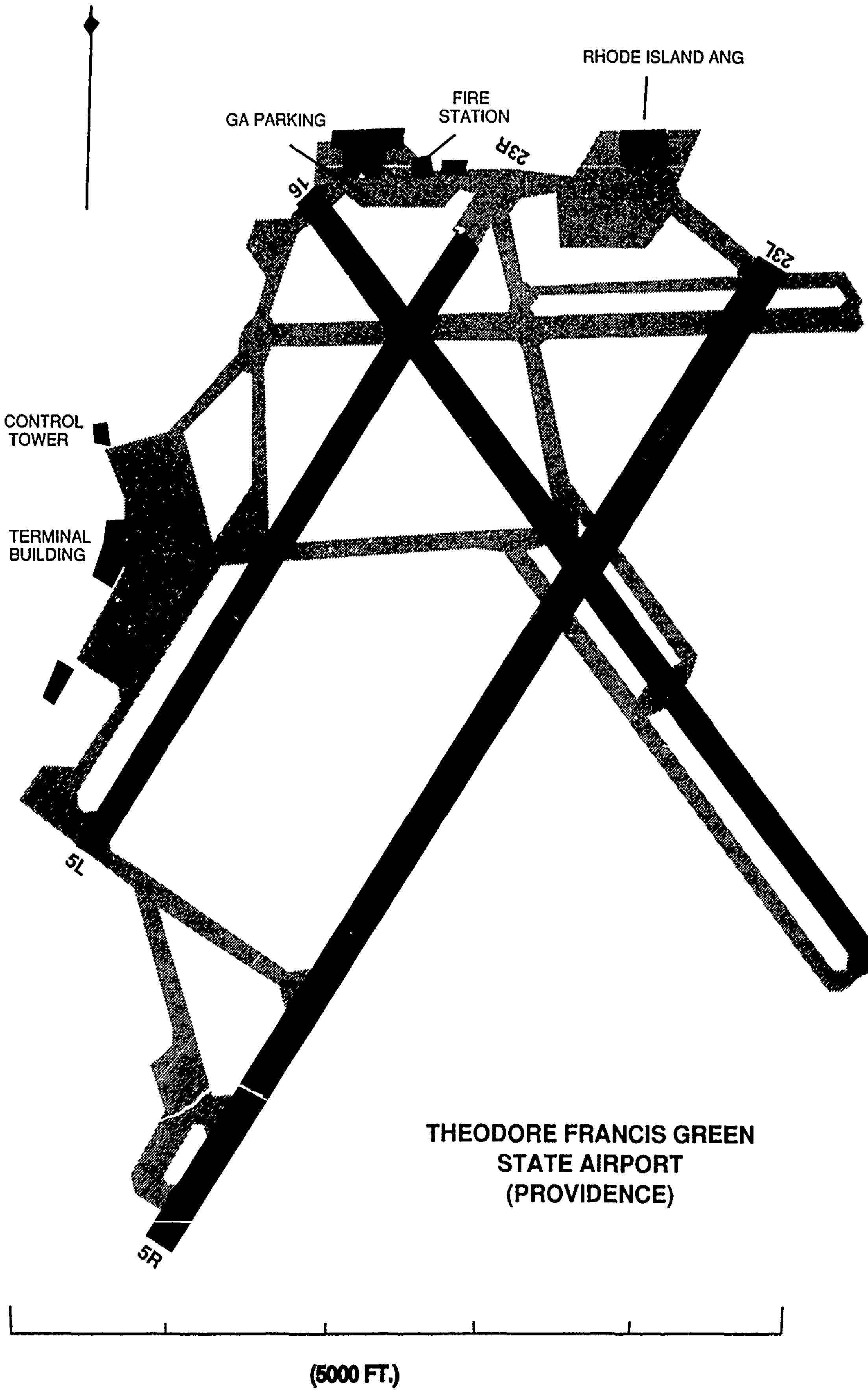


SACRAMENTO METROPOLITAN AIRPORT

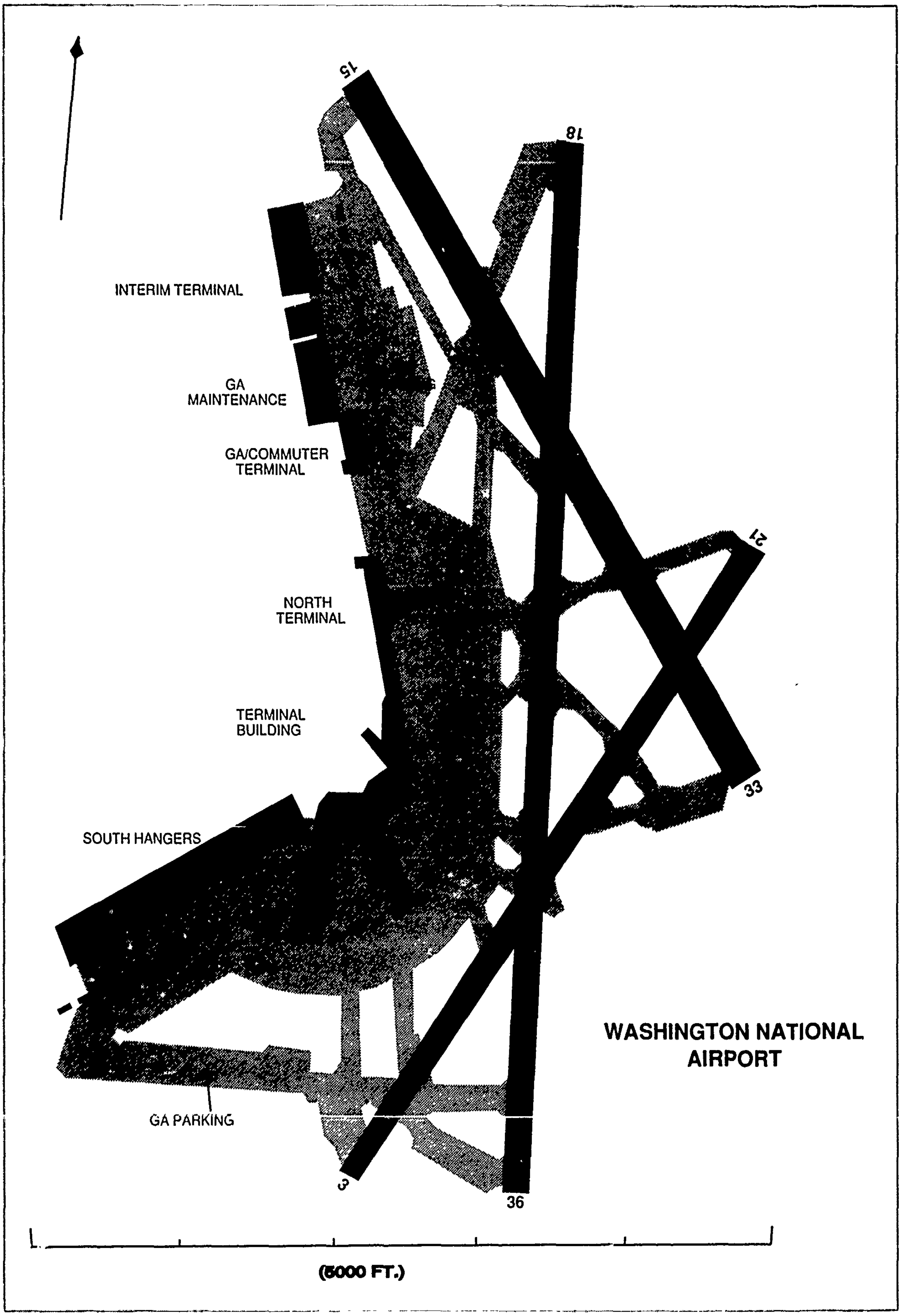


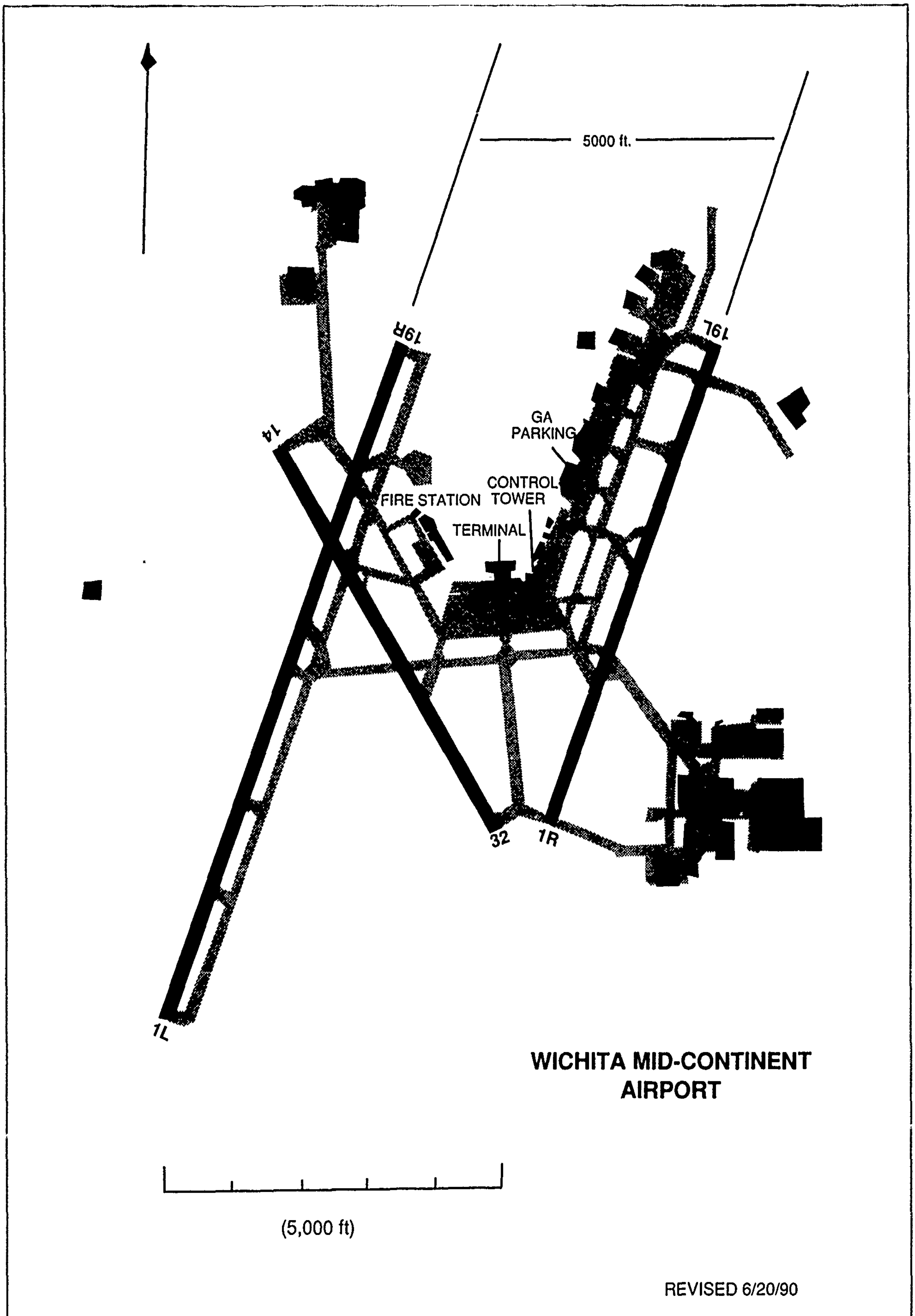
12R
12L
CONTROL TOWER
TERMINAL BUILDING
FIRE STATION
3
30L
30R
21
SAN ANTONIO INTERNATIONAL AIRPORT
(5,000 ft)


9
WEST
TERMINAL
EAST
TERMINAL
CONTROL
TOWER
FIRE
STATION
13
SAN DIEGO
INTERNATIONAL-LINDBERGH FIELD
AIRPORT
US COAST GUARD
AIR STATION
US CUSTOMS
31
GA PARKING
27
(5,000 ft)



THEODORE FRANCIS GREEN
STATE AIRPORT
(PROVIDENCE)


15
18
INTERIM TERMINAL
GA MAINTENANCE
GA/COMMUTER TERMINAL
21
NORTH TERMINAL
TERMINAL BUILDING
33
SOUTH HANGERS
WASHINGTON NATIONAL AIRPORT
GA PARKING
3
36
(5000 FT.)


5000 ft.
19R
19L
14
GA
PARKING
CONTROL
TOWER
FIRE STATION
TERMINAL
32
1R
1L
WICHITA MID-CONTINENT
AIRPORT
(5,000 ft)
REVISED 6/20/90

Appendix E

Potential New IFR Approach Procedures and Associated IFR Arrival Capacity

This appendix presents the results of an analysis of the potential applicability of the five multiple approach procedures described in Sections 3.1.1.1 through 3.1.1.5 at the top 100 U.S. airports. The analysis was performed by inspecting runway approach diagrams only; considerations such as noise, obstructions, and community concerns were not used in the analysis.

Table E-1 shows the applicability of current and proposed procedures for each airport. The first column to the left shows the current best hourly arrival capacity and the approach procedure used to achieve that capacity. The following four columns show which of the five proposed procedures are applicable.

Some airports may not actually be using their "current best" approach procedures. Likewise, the actual aircraft fleet mix at each airport was not used; the capacity figures used are good approximations of real capacity. The objective of the table is to provide initial information on the applicability of approach procedures being developed by the FAA. The estimated capacity numbers should be used to compare one alternative procedure to another.

An asterisk (*) in the column indicates that the proposed approach procedure is applicable at a given airport. A superscript "P" indicates that the approach procedure may be applicable if and when proposed construction/extension plans actually take place. Some of this construction is in progress, while other construction is only at the proposal stage.

A blank space indicates that either the current runways do not support the proposed procedure; it is a borderline application; or there is not enough information to determine applicability.

Finally, an asterisk was replaced by a capacity number wherever a new approach procedure can provide better capacity than any other method (current or proposed) at a given airport. The number indicates the hourly arrival capacity of the procedure in question.

The most beneficial improvement can be found by looking at the "New Approach Procedure" section in each row.

Table E-1 Potential of New IFR Approach Procedures and Associated IFR Arrival Capacity[1]

Airport City and Code	Current Best IFR Arrival Capacity (Approach Procedure)[2]	NEW APPROACH PROCEDURES[3] Dependent Parallel	Independent Parallel	Dependent Converging	Triple
Agana (Guam) NGM	26 (S)				
Albany ALB	26 (S)			34	
Albuquerque ABQ	26 (S)				
Anchorage ANC	26 (S)				
Atlanta ATL	52 (IP)	*	*p		63p - 78
Austin AUS	26 (S)			34	
Baltimore BWI	26 (S)		52p	*	
Birmingham BHM	26 (S)				
Boise BOI	26 (S)				
Boston BOS	26 (S)	36		*	
Buffalo BUF	26 (S)			34	
Burbank BUR	26 (S)			34	
Charleston CHS	26 (S)			34	
Charlotte CLT	52 (IP)	*p	*p	*	
Chicago MDW	26 (S)				
Chicago ORD	52 (IP)				78
Cincinnati CVG	26 (S)	*	*	*	63p - 78
Cleveland CLE	26 (S)			34	
Colorado Springs COS	26 (S)		*p	*	
Columbia CAE	26 (S)			34	
Columbus CMH	36 (DP)				
Dallas DAL	36 (DP)		52		
Dallas-Fort Worth DFW	52 (IP)				78p
Dayton DAY	52 (IP)			*	
Denver DEN	52 (IC)	*			
Des Moines DSM	26 (S)			34	
Detroit DTW	52 (IP)	*		*p	63p - 78
Ei Paso ELP	26 (S)	*			
Fort Lauderdale FLL	26 (S)		52	*	
Fort Myers RSW	26 (S)		52p		
Grand Rapids GRR	26 (S)		52p		
Greensboro GSO	26 (S)		52p	*	
Greer GSP	26 (S)				
Harlingen HRL	26 (S)		*	*	
Hilo ITO	26 (S)			34	
Honolulu HNL	52 (IP)			*	
Houston HOU	26 (S)			34	
Houston IAH	52 (IP)				78p
Indianapolis IND	26 (S)	36p		*	

Table E-1 Potential of New IFR Approach Procedures and Associated IFR Arrival Capacity[1] (continued)

Airport City and Code	Current Best IFR Arrival Capacity (Approach Procedure)[2]	NEW APPROACH PROCEDURES[3] Dependent Parallel	Independent Parallel	Dependent Converging	Triple
Islip ISP	26 (S)			34	
Jacksonville JAX	26 (S)				
Kahului OGG	26 (S)			34	
Kailua-Kona KOA	26 (S)				
Kansas City MCI	26 (S)		*p		
Knoxville TYS	26 (S)	36			
Las Vegas LAS	26 (S)			34	
Lihue LIH	26 (S)			*	
Little Rock LIT	26 (S)		*p		
Long Beach LGB	26 (S)	*	52	*	
Los Angeles LAX	52 (IP)				
Louisville SDF	26 (S)		52p	*	
Lubbock LBB	26 (S)				
Memphis MEM	36 (DP)		*	*	
Miami MIA	52 (IP)			*	
Midland MAF	26 (S)	*		*	
Milwaukee MKE	26 (S)	*		*	
Minneapolis-St. Paul MSP	36 (DP)		52	*	
Nashville BNA	52 (IP)	*		*	
New Orleans MSY	26 (S)		*p		
New York JFK	36 (DP)		*	*	
New York LGA	26 (S)			34	
Newark EWR	26 (S)			*	
Norfolk ORF	26 (S)			34	
Oakland OAK	26 (S)	*			
Oklahoma City OKC	52 (IP)				
Omaha OMA	26 (S)	36		*	
Ontario ONT	26 (S)				
Orlando MCO	52 (IP)	*			78p
Philadelphia PHL	52 (IC)	*	*p	*	
Phoenix PHX	26 (S)		52		
Pittsburgh PIT	52 (IP)	*		*	63p - 78
Portland PDX	36 (DP)		52	*	
Portland PWM	26 (S)			34	
Providence PVD	26 (S)	36		*	
Raleigh-Durham RDU	36 (DP)		*	*	63p
Reno RNO	26 (S)			34	
Richmond RIC	26 (S)				
Rochester ROC	26 (S)			*	

Table E-1 Potential of New IFR Approach Procedures and Associated IFR Arrival Capacity[1] (concluded)

Airport City and Code	Current Best IFR Arrival Capacity (Approach Precedure)[2]	NEW APPROACH PROCEDURES[3] Dependent Parallel	Independent Parallel	Dependent Converging	Triple
Sacramento SMF	52 (IP)				
SaltLake City SLC	36 (DP)		*		63P
San Antonio SAT	26 (S)			*	
San Diego SAN	26 (S)				
San Francisco SFO	26 (S)			34	
San Jose SJC	26 (S)				
San Juan JU	26 (S)				
Santa Ana SNA	26 (S)				
Sarasota-Bradenton SRQ	26 (S)				
Savannah SAV	26 (S)		52P	*	
Seattle SEA	26 (S)	36P			
Spokane GEG	26 (S)			34	
St. Louis STL	26 (S)	*		*	
Syracuse SYR	26 (S)		52P	*	
Tampa TPA	52 (IP)			*	
Tucson TUS	26 (S)				
Tulsa TUL	52 (IP)			*	78P
Washington DCA	26 (S)			34	
Washington IAD	52 (IP)				78
West Palm Beach PBI	26 (S)			34	
Wichita ICT	52 (IP)				
Windsor Locks BDL	26 (S)				

1. Generic (not airport-specific) capacities are used here, to provide a basis for comparison only. These capacities, derived through the FAA Airfield Capacity Model, use a "standard" aircraft mix. Other factors, such as winds and noise contraints, are not taken into account.
2. Current Best Approach Procedure Abbreviations:
   - S - Single Runway Approach
   - IP - Independent Parallel
   - DP - Dependent Parallel
   - IC - Independent Converging
3. - An Asterisk (*) indicates that new approach procedures are proposed, however, it also means that either the current best approach procedure, or another proposed procedure (under new rules), provides equal or better arrival capacity.
   - A Number indicates the hourly arrival capacity provided by a new approach procedure, when such capacity is larger than the one provided by other procedures (current or new).
   - A Superscript "P" indicates that the approach procedure will be applicable if and when planned runway construction/extensions take place.

Appendix F

New Technology for Improving System Capacity

The major purpose of the R, E&D program is to manage an expanding volume of air traffic with improved safety, reduced delays, and minimal operational constraints.

Major 1989 Accomplishments

During 1989 the FAA's Capacity R,E&D program made many significant advances.

- Prototype surveillance radars with increased update rates were installed at Raleigh-Durham and Memphis to examine their ability to monitor flight paths for independent, simultaneous approaches to closely-spaced parallel runways. These systems can potentially provide an estimated 30 percent increase in capacity at those sites during IFR.
- Airport capacity improvement studies supported by FAA planning and analysis tools were completed at Atlanta, San Francisco, Detroit, St. Louis, Miami, and Kansas City. As a result, new runways are being planned at four of these airports.
- Potentially significant capacity gains through more efficient use of runways were simulated using a prototype converging-approach spacing aid.
- Recently completed computer-based analytical models were applied successfully to evaluate terminal area airspace designs at the Los Angeles, Boston, Dallas/Fort Worth, Denver, and Chicago air traffic centers.

Current Program

The major emphasis of the program is to close the gap between IFR and VFR capacities while maintaining maximum VFR capacity. Complete project details, including funding and implementation dates where appropriate, are given in the following project sheets. The key elements of the R,E&D capacity program are:

- Continued development of precision landing monitors and procedures permitting independent IFR approaches to closely-spaced parallel and converging runways.
- Continued development of terminal area and airport surface traffic automation, which seeks to prevent runway incursions and improve surface traffic management. The terminal area automation activity will employ modern computer displays and computational power for increased terminal area capacity and safety. Both systems will be integrated into the Advanced Automation System under current development.
- Continuation of the ambitious schedule of airport capacity design team studies.
- Continued analysis and study of methods and procedures to use triple and quadruple parallel approaches at selected airports.
- Further application of airspace models and traffic flow simulations for the determination of optimal airspace structure and procedures to enhance capacity.
- Aggressive pursuit of a program to determine means and procedures to alleviate the adverse impacts of aircraft wake vortices on airport capacity.
- Continuation of efforts to improve airport pavements, runway maintainability, and surface lighting and marking to reduce runway and taxiway occupancy time.

Table F-1. Funding Summary ($000) For FY90 Appropriations

Title	FY90 Appropriation	FY91 Budget Request
SIMMOD	1,465	1,355
NASPAC	2,363	2,516
Airspace System Models	773	946
Terminal ATC Automation	6,788	7,582
Airport Surface Traffic Automation	2,343	4,082
Capacity Development	2,784	2,831
Wake Vortex Avoidance	1,570	1,876
Precision Runway Landing Monitor	2,031	2,000
Airport Pavement	2,080	1,905
Airport Surface Visibility Control	1,149	1,595
Reduced Runway Occupancy	1,006	1,545
Airport Capacity Task Forces	565	2,151
Airport Capacity Enhancement	2,156	1,138
Terminal Landside Traffic Modeling	352	575
Total	**27,296**	**32,097**

F.1 Terminal Airspace Capacity Related Projects

The following sections summarizes on-going projects designed to improve the capacity of the airspace surrounding major cities.

F.1.1 Terminal Radar (ASR) Replacement Program

F.1.2 Los Angeles Basin Consolidation

F.1.3 Simulation Model Development (SIMMOD)

F.1.4 Terminal ATC Automation (TATCA)

F.1.5 Airport Surface Traffic Automation (ASTA)

F.1.1 Terminal Radar (ASR) Replacement Program

Contact Person:
Carmine Primeggia, 202/267-8480

Purpose

To replace all 96 airport surveillance radar (AIR)-4/5/6 systems together with associated air traffic control beacon interrogator (ATCBI)-3 equipment.

The replacement equipment shall be designed to meet current operational requirements and shall include remote maintenance monitoring and a separate six level weather channel. The stand-alone, receive-only weather channel is an integral part of the ASR-9 and will provide six levels of weather. Each controller will be able to select individually any two of the six levels for display on the existing displays.

The ASR-4/5/6 radars were originally procured in 1958. The first system was commissioned in 1960 and the last in the 1964-65 timeframe. The ATCBI-3 is of comparable vintage. Thus, the average age of the hardware is currently 20 years; the design, which has an inherent and basic limitation on system performance, is over 20 years old. Radar detection range for small aircraft in the clear varies from 25 to 35 nautical miles depending on aircraft course, attitude, position in the antenna beam, etc. The probability of detecting A/C on a tangential course is marginal at any range. Processing of weather data for display is not provided.

Products	Commitment Date
• Issue Westinghouse contract	2/90
• First operational ASR 7/8	4/90
• System delivered to last operational site	2/92
• First Operational Position Standards (OPS) site delivery — sole source	4/92
• Last site acceptance test completed	6/92
• Last Operational Readiness Demonstration (ORD) completed (N.P. 12/92)	6/92
• First ORD completed — sole source	7/92
• Last operational ASR 7/8 relocate (N.P. 4/93)	11/92
• Last OPS site delivery — sole source	4/92
• Last ORD completed — sole source	892

F.1.2 Los Angeles Basin Consolidation

Contact Person:
Frank McArthur, 202/267-8680 or
Bill Henshaw FTS/984-0220

Purpose

To consolidate four Los Angeles Basin Terminal Radar Approach Control facilities (TRACONS) to enhance traffic management in Southern California and allow more efficient use of the airspace.

The Los Angeles Basin is created by the Pacific Ocean and the San Rafael, Sierra Madre, Techachapi, San Gabriel, San Bernardino, San Jacinto, and Santa Ana Mountain ranges. The basin area is approximately 75 miles wide and 100 miles long. Instrument operations in Southern California have increased 122 percent over the last 2 years. The combination of increased traffic and airspace complexity necessitates regulatory airspace action in, and adjacent to, the Los Angeles Basin.

The major portion of this airspace below 10,000 feet is currently controlled by TRACON facilities located at Los Angeles, Burbank, El Toro, and Ontario. These four TRACON facilities provide instrument flight rule services for 21 airports within their respective areas of jurisdiction. This includes five major air carrier airports and three military air fields.

Studies addressing the consolidation of terminal radar approach control facilities in the Southern California area can be traced back to the early 1970's. These studies addressed individual facility requirements to improve arrival and departure control procedures, without focusing on the entire Southern California area. Working groups were formed to develop a systems approach to the growing, complex problem of providing optimum service to the maze of airports located in the basin area. In fiscal year 1988, 2,234,500 instrument operations were recorded, and the forecast calls for well over 3,000,000 by the year 2000.

Products

This consolidation will enhance safety, improve airspace utilization, and provide an IFR air traffic control system approach for the major hub and satellite reliever airports in Southern California.

	Commitment Date
Start site adaptation	1/90
Building contract award	12/90
Building occupancy date	12/92
Los Angeles TRACON consolidated	12/93
Coast TRACON consolidated	05/94
Burbank TRACON consolidated	10/94
Ontario TRACON consolidated	12/94
Project completed	5/95

F.1.3 Simulation Model Development (SIMMOD)

Responsible Division: AOR-200
Contact Person:
Steven J. Wolf, 202/267-3541

Purpose

To provide an accurate, comprehensive, and cost-effective analytical tool for evaluating proposed improvements to the national airspace system.

This capability will provide quantitative analyses to determine the impact of proposed changes to airports, airspace, and aircraft traffic. Training and documentation will be developed on model use. SIMMOD is expected to play a significant role in future development of the national airspace system by reliably identifying the most appropriate airport and airspace design and procedural alternatives.

SIMMOD will be enhanced with logic improvements that will increase realism in simulating the actual behavior of the air traffic control system and air operations. The cost of extensive data preparation will be reduced by developing automated data-acquisition hardware and software. Visual replay of scenarios will continue to be developed as an effective quality-control technique and for specific site calibration. Full documentation of the model's algorithms will be provided, as well as training manuals and courses, so that the model may be widely used by the FAA and others to improve designs and procedures in the airspace system. A users group will be formed to share experiences with the model and to identify needed improvements.

Progress/Activity

Version 1.0 of SIMMOD was publicly released and validated in FY 1989, and was applied to airspace design tasks such as the Los Angeles Center restructuring study and similar analyses of the air traffic control centers around Boston, Dallas/Ft. Worth, Denver, and Chicago. Enhancements to SIMMOD were also initiated in FY 1989.

For FY 1991, applications work will continue for both airport and airspace environments. Additional model logic enhancements to more realistically simulate aircraft movements through airports and the airspace will be accomplished. A computer work station version of the simulation model will be completed, along with user manuals and full documentation of the model's algorithms. Work will also begin on an interactive user-friendly version to assist air traffic control planners in procedures training and the evaluation of new airspace configurations.

Products

- Complete computer program for microcomputers and work stations
- An organization of users throughout the FAA and industry
- Training manuals and technical documentation for users

F.1.4 Terminal ATC Automation (TATCA)

Responsible Division: ARD-100
Contact Person:
Malcolm Burgess, 804/864-1905

Purpose

To develop air traffic control (ATC) automation aids to assist ATC controllers and supervisors to more fully use available terminal airspace capacity, and to increase the safety and efficiency of aircraft operations into and out of terminal areas.

TATCA will help air traffic controller teams at major airports handle larger volumes of departing and landing aircraft, particularly under Instrument Meteorological Conditions (IMC). The principal automation function being investigated is a comprehensive traffic planning and controller coordination aid known as the TATCA Dynamic Traffic Planner (DTP). A related TATCA activity is the accelerated development of a final approach spacing aid, specifically for airports with converging approaches.

Spacing aids will suggest specific speed changes or turn-to-final commands for bringing aircraft into compliance with the landing plan, and for more precisely spacing aircraft on final approach. The converging-approach delivery aid, a specific application of the final-spacing advisor, will assist controllers in feeding staggered approach streams to converging runways. This will allow more beneficial use of converging approaches under IMC conditions, and continued use of multiple runways under lower ceilings.

The TATCA planning and advisory system will complement the FAA's current En Route Metering (ERM) system, the planned En Route Spacing Program (ESP), and the Arrival Sequencing Program (ASP). These programs are intended to deliver en route aircraft to the TRACON boundary at a manually specified average hourly rate. TATCA, in contrast, will provide assistance to the controllers and supervisors all the way to the runway by planning individual trajectories and a specific, efficient landing sequence, aircraft by aircraft.

The DTP will present its products to individual members of the terminal controller team in the form of coordinated displays of aircraft arrival times and landing sequences. The DTP will provide assistance to the controllers in the en route facilities adjacent to the terminal, as well as inside the terminal area feeder fixes. This will assure a steady flow of traffic that matches the landing plan. It will also determine the dynamic capacity of the terminal, based on accurate observation and prediction of wind and individual aircraft movements.

Automatic plan updates based on radar surveillance data will reflect changes in aircraft locations and speeds. The DTP will derive current traffic demand information from surveillance, flight plan, and manual input data (e.g., runway configuration, visibility, and hazardous weather). It will use this information to suggest acceptance rates and other important planning measures to supervisory personnel. A plan conformance indicator will display the amount of time by which each aircraft has deviated from the schedule.

An important feature of the traffic planner will be its ability to calculate efficient landing sequences. When traffic demand is heavy in IMC, the traffic planner will suggest aircraft landing orders that will reduce the average in-trail spacing by exploiting the predictable differences in landing intervals caused by factors such as wake-vortex separation and landing speed.

TATCA will help controllers meet the plan provided by the DTP by means of speed-control and holding advisories, descent advisories, supervisors' displays, and final-spacing aids. ATC coordination will be facilitated by sharing the traffic plan, its associated database, and the advisories as appropriate among all relevant supervisory and control positions. When available, data link will allow much more efficient

transmission of relevant information to the participating aircraft. A customized local display of the landing plan will be provided to each controller and supervisory position.

The TATCA functions will be implemented for evaluation at the first operational site according to a phased development plan. The first phase will provide a single overall DTP display and supervisor display in the TRACON, and in the Traffic Management Unit of the adjacent en route center(s). Successive implementation phases will display planning and advisory information to more individual radar controllers in the extended terminal area.

Progress/Activity

The TATCA program was initiated in FY 1988. Accomplishments in FY 1989 included the demonstration and laboratory prototype development of a converging-approach spacing aid. Progress in FY 1989 included: (1) the development of a potential technique for accurately estimating winds aloft from observation of radar surveillance data; (2) the prototype development of accurate and computationally efficient aircraft path/time predication algorithms and models appropriate for use in terminal airspace; and (3) the demonstration of initial display concepts for the TATCA DTP and supervisor's display. In FY 1990, initial TATCA planning and advisory aids will be integrated into a rapid prototype laboratory at the contractor's facility. In addition, the final approach spacing aid for converging approaches will be evaluated in a laboratory environment and preparations will begin for evaluation of a prototype capability at the FAATC. In FY 1991, alternative controller display and machine interface concepts will be analyzed, and selections made for a more extensive evaluation and demonstration to be conducted.

The major new effort in FY 1991 will be the real-time testing of the TATCA logic with live radar and flight plan data at the FAATC. This will be the first step in the development of real-time TATCA software capable of operating with live surveillance data. This software will include all of the capabilities that will eventually be required of operational TATCA software.

In FY 1993-1997, the TATCA design will be extended to more complex environments, such as terminals with multiple major airports within a single terminal region, and large airports with configurations of multiple parallel runways. Evaluation of the initial arrival planning functions of the TATCA system concept is planned to begin in FY 1993. Evaluation of the integrated arrival/departure planning function and controller advisories is expected the following year. The results of these evaluations will provide the basis for the preparation of specifications for operational implementation.

Products

- Dynamic Traffic Planner (DTP) including controller advisories software and controller interfaces
  - Final-spacing aids
  - Converging-approach delivery aid
  - Speed control and holding advisories
  - Descent advisories
  - Supervisors' displays
- TATCA evaluations in rapid prototyping laboratories
- FAATC evaluations
- Specifications to support national implementation

F.1.5 Airport Surface Traffic Automation (ASTA)

Responsible Division: ARD-100
Contact Person: Lou Pelish, 202/267-9849

Purpose

To develop airport surface surveillance, communications, and automation techniques that will provide an effective runway incursion prevention capability.

To provide departure traffic management to sequence aircraft to the departure end of the runway according to schedules designed to expedite traffic flow and increase the capacity of the airport surface in all weather conditions.

ASTA improvements will be developed in three phases. Phase 1 will focus on the prevention of runway incursions based on use of radar surveillance, runway/taxiway signal lighting, and an interface for the tower controller, providing appropriate advisories and alerts regarding aircraft movements.

In Phase 2, the automation equipment will monitor aircraft movements for conformance to assigned taxi routes. Initial elements for the departure traffic management capability will be introduced in Phase 2.

Phase 3 will utilize Mode S surveillance on the airport surface to provide aircraft identification data, (i.e., call sign), as well as a data-link communications capability. Phase 3 also will provide a comprehensive taxi routing and departure management capability, integrated with the arrival traffic management functions of Terminal Air Traffic Control Automation (TATCA).

Progress/Activity

The ASTA project was started in FY 1989 to reduce the risk of runway incursions, and improve airport capacity through better departure traffic management and increased efficiency of aircraft surface movements. In FY 1989, a safety analysis of runway incursion incidents was completed as an initial step in requirements development. In addition, work began on identifying alternative capabilities for reducing runway incursions.

In FY 1990, promising alternatives will be selected for more in-depth development and design. Evaluations will be initiated on a transportable, integrated Airport Surface Detection Equipment ASDE/Mode S data-link testbed. FY 1991 will focus on the development of a rapid-prototyping laboratory, the implementation of proposed ASTA designs in the laboratory for evaluation, and construction of the initial elements of the ASDE/Mode S testbed.

Products

- Operational concepts
- System descriptions (Phases 1, 2, and 3)
- Rapid-prototyping laboratory
- Field evaluations
- System evaluation reports
- System specifications

F.2 Other Capacity-Related Topics

F.2.1 FAA National Simulation Laboratory (NSL)

Responsible Division: AOR-100
Contact Person:
Herbert Goldstein, 202/267-3411

Purpose

To optimize the horizontal integration of National Airspace System (NAS) subsytems, procedures, and airspace to increase total safety and efficiency, and meet the demands of the 21st century.

New concepts such as the combined use of the Microwave Landing System, Traffic Alert and Collision Avoidance System, and high-return-rate radar to reduce separations and minimums which were tested at several sites will be tested for feasibility and for acceptability to pilots and controllers, all at one location. Tests cannot be run on a live environment, but must be simulated in a realistic situation prior to deployment. The simulation laboratory will also support the more detailed integration of future hardware configurations into the NAS.

The FAA will establish a laboratory to test and evaluate proposed future subsystems, aviation procedures, airspace organization, and human factors in an integrated fashion to determine the definition of the 21st-century NAS. This will involve using as much existing and planned Facilities and Equipment (F&E) and configurations as possible in order to avoid duplication, contain costs, and provide maximum realism. The program will provide a means for testing and evaluating alternative concepts for potential NAS development, as well as a capability for hands-on development of prototype configurations for future NAS integration.

Progress/Activity

In FY 1990, the FAA will determine the system definition design and identify alternative system configurations for analysis and evaluation. A small-scale integration laboratory will be established to serve as the initial horizontal integration facility for proof-of-concept demonstrations.

In FY 1991, the FAA will proceed with an initial capability to demonstrate the synergistic effects of NAS equipment integration in the New York airspace/airport environment. This proof-of-concept definition will assist in demonstrating the high payoffs associated with a fuller operational NSL.

Products

- Simulations of optimized NAS configurations

F.2.2 Dynamic Special-Use Airspace Management

Contact Person:
Carey L. Weigel/William H. Wade

Purpose

To develop procedures and define automation requirements for increasing flexibility in Dynamic Special-Use Airspace (DSUA) allocation and use

The FAA is working closely with Department of Defense, who will use FAA data in the development of a Military Airspace Management System (MAMS).

The activation and release of DSUA, such as restricted airspace and military operations areas, is currently limited by several factors, including manual interagency coordination. The allocation and control of DSUA are therefore not always totally responsive to either military or civilian needs. New ATC procedures and the necessary automation requirements will be developed for improved management of DSUA.

Progress/Activity

Interagency coordination procedures were examined in FY 1989 to identify functional and performance requirements for a more dynamic DSUA management function. A draft report on DSUA operational procedures, current limitations, and recommendations for improvement will be completed in FY 1990. This report will form the basis for further development activities and for integration with the national ATC flow management process.

Products

- In FY 1991, requirements will be developed for the database structure and communications necessary to dynamically manage DSUA.
- In FY 1991, requirements will be developed for the necessary ATC automation at both the ATMS and AAS levels to support improved DSUA operational procedures. Automation requirements will cover several technical areas, including:
  - Assessment of the national and local impacts of the activation and release of DSUA, based on number and identity of aircraft affected. Flow management alternatives will be examined that will reduce the number of and degree to which aircraft are affected.
  - Dynamic definition of DSUA to satisfy emergency or high-priority requirements.
  - Accommodation of noninterfering military user-preferred trajectories to and from a DSUA at the area control facility level.
- Report on DSUA operational procedures, current limitations, and recommendations for improvement.
- Report on DSUA air traffic control database and communications requirements.
- Report on DSUA for ATC automation functional requirements.

F.2.3 National Airspace System Performance Analysis Capability (NASPAC)

Responsible Division: AOR-100
Contact Person:
Arturo Politano, 202/267-7016

Purpose

To achieve a long-term analysis capability through the application of modern tools of operations research and computer modeling to develop, design, and manage the nation's airspace on a system-wide level.

This capability will identify the limiting factors in national airspace system performance, and provide quantitative analysis to determine the impact of proposed changes on the overall aviation system, while offering useful information to decision makers and strategic planners.

The NASPAC includes simulation and analytical queuing models. The simulation model simulates the movement of individual aircraft through the nationwide network of airports, navigation fixes, routes, and sectors; the analytical queuing model is based on mathematical formulas of queuing theory. The simulation model incorporates the general structure of the national airspace system as a system of 58 selected airports, 48 arrival and departure fixes, and all of the 630 en route sectors. It also considers en route flow restrictions, the effects of instrument meteorological conditions at airports, and additional details.

Progress/Activity

In FY 1989, the simulation model was enhanced and validated by comparing results with real-world data on system performance. Several specific system performance analyses were performed using these models. Studies of system impacts of the Dallas/Ft. Worth Metroplex expansion, the proposed new Denver Airport, and southern California airspace, were completed. In FY 1990, the impact of airline hubbing, proposed new airports, and future congested airspace and airports in the national airspace system will be analyzed. The development of a weather annualization capability to analyze long-term effects will be undertaken in FY 1991.

A simplified, user-friendly desktop version of the NASPAC will also be available, requiring only minimal training and preparation. Improvements in airspace design and management will be a direct result of these efforts. The models will be enhanced, as required, for specific FAA applications regarding system performance. NASPAC will be included in the National Simulation Laboratory.

Products

- Model documentation and validation
- NASPAC simulation model enhancement
- System impacts of airline hubbing and proposed new airports
- Identification of future congested airspace and airports
- Desktop version of NASPAC
- Weather annualization
- Southern California airspace analysis

F.3 En-Route Capacity Related Projects

F.3.1 Airspace System Models

Responsible Division: AOR-10
Contact Person: Ken Geisinger, 202/267-7568

Purpose

To develop analytic models, including computer simulations, for evaluating current and future impacts of proposed new National Airspace System (NAS) equipment, air traffic control (ATC) procedural changes, and revised airspace configurations.

The models will provide quantitative measurements of system performance in terms of safety, capacity, efficiency, and controller workload. This program supports provisions of the Aviation Safety Research Act of 1988, which requires development of models of the ATC system to predict safety and capacity problems. Models developed will emulate the airspace system with a high level of detail and fidelity.

This project develops analytic approaches and automated tools for storing, retrieving, and processing the massive amount of data required for analyses of the ATC system. The models will share common elements, but will be tailored for specific ATC needs and users. For example, the first product will be a tool for use by en route airspace designers to evaluate the impact of alternative designs on controller workload. Later products will address terminal airspace, to allow analyses of proposed changes in procedures, regulations, and airspace design in terms of safety, efficiency, and controller workload. Other products will address the impacts of proposed new NAS equipment and automation on the ATC environment.

Progress/Activity

In FY 1989, initial efforts to develop a work plan for the design of the prototype model were completed. Work in FY 1990 will focus on developing a prototype en route sector evaluation model.

Focus will then be expanded to include development of a terminal airspace evaluation tool in FY 1991, along with other interactive tools for use by ATC planners.

Products

- En route sector design tool
- Terminal airspace evaluation tool
- ATC automation model
- NAS equipment evaluation model
- Tools for processing, storing, retrieving, and displaying data

F.3.2 Airspace and Traffic Optimization: Dynamic Ocean Tracking System (DOTS)

Responsible Division: ARD-100
Contact Person: David Ford

Purpose

To minimize fuel consumption, facilitate aircraft operations for users and the ATC system, and improve ATC designs and procedures by developing a tool to optimize flight track design and track utilization.

Approach

Computer efficient algorithms have been developed which determine an aircraft's projected time and fuel consumption over the ocean given the operating conditions. Optimization techniques use these algorithms together with an automatic dynamic weather database, and varying ATC separation criteria, to design flexible fuel efficient tracks for oceanic traffic. A similar process is used to advise individual scheduled flights of the optimal track based on their oceanic entry time and other aircraft traffic they will encounter.

Progress/Activity

In FY 1989, simulated and actual flight testing began. A prototype system was installed at the Oakland Center.

In FY 1990, flight tests will continue in airspace controlled by the Oakland and Tokyo centers, to verify the projected fuel burn and time savings for the scheduled air carriers. These flight tests will be completed at Oakland Center in FY 1990. A prototype system will be operated in the Central Pacific for extended evaluation. In FY 1990 test systems will also be installed in the New York and Anchorage Oceanic Areas, and in FY 1991 initial flight testing will begin. In FY 1991, Dynamic Ocean Track Systems (DOTS) capability will begin to be integrated in the Enhanced Traffic Manager.

Products

- Algorithms for minimum fuel path generation for an arbitrary set of position, altitude, velocity, and time constraints
- Prototype hardware and software
- Algorithms and operational guidelines for minimum fuel computations within the oceanic ATC system
- Dynamic simulation model
- Applications

F.3.3 Oceanic Display and Planning System (ODAPS)

Contact Person: Delois Smith, 202/267-8347

Purpose

To provide an automated conflict probe that will allow controllers to assign routes and altitudes to better advantage without revising separation standards.

Implementation of oceanic automation includes a display and a stand-alone processor.

Oceanic controllers in facilities on the East and West Coasts of the United States are confronted with an increasing number of random and unorganized flight tracks, and are not able to maximize the spatial relationships of aircraft from data presented on current flight progress strips or plotting boards. Oceanic display and planning systems will be provided that will reduce this problem by providing controllers with adequate information to apply separation standards in a timely manner. Requirements validation and design has been completed. Systems have been delivered to both sites, and Site Acceptance Tests have been conducted.

Progress/Activity

The contractor has resolved all high and critical priority software (S/W) problems identified to date. A firmware modification to the GFE (FDIO) peripheral equipment was implemented, and the second User Acceptance test (UAT) was conducted. AAP-300 CCB approved 15 NCPs on September 15, 1988. These NCPs are enhancements to the basic system and are deemed necessary by Air Traffic to fully implement ODAPS. The schedule was re-baselined to reflect the impact of the ATR enhancement requirements. The final ORD is expected to occur in October 1990, after implementation of all 15 project enhancements.

The ODAPS contract options have been exercised for the New York ARTCC and the FAATC test bed.

Products

Oceanic display and flight data automation for two ARTCC's.

• Acceptance (S/W) (Package I)	9/89
• Acceptance (S/W) (Package I & II)	2/90
• Acceptance (S/W) (Package I, II, III)	6/90
• SYS delivered to last operational site (ZNY) (Package I, II, III)	7/90
• Site integration test complete (IOC) (ZOA) (Package I & II)	2/90
• ORD (ZOA) (Package I & II)	4/90
• Last integration test complete (IOC) (ZNY) (Package I, II, III)	9/90
• Last ORD complete (ZNY) (Package I, II, III) (N.P. 06/91)	10/90
• ZNY S/W handoff to ATR-200	10/90
• ZOA S/W handoff to ATR-200	10/90

F.3.4 Traffic Management System (TMS)

Responsible Division: ANA-130
Contact Person: Harry B. Kane, 202/267-8336

Purpose

To upgrad the present flow control system into an integrated Traffic Management System (TMS) which operates at the national level through the Central Flow Control Facility (CFCF), and the local level through traffic management units (TMUs).

The upgrading of the traffic management system is designed to improve air traffic system efficiency, minimize delays, expand services, and be more responsive to user requirements. The TMS functions include: Central Altitude Reservation Function (CARF); Airport Reservation Function (ARF); Emergency Operations Facility (EOF); Central Flow Weather Service Unit (CFWSU); various flow management programs with integrated metering functions such as the Departure Sequencing Program (DSP), En route Spacing Program (ESP), the Arrival Sequencing Program (ASP); and Enhanced TMS (ETMS) functions including the Aircraft Situation Display (ASD) and Monitor Alert (MA).

Progress/Activity

Phase I of the TMS program has been completed, and provided replacements of outdated computer systems, implementation of a data communications system to interface users and ARTCC computers in a two-way data mode inter-facility flow control network (IFCN), and relocation of CARF and the automation staff to FAA headquarters.

Phase II has provided the Enhanced Traffic Management System, which is a computer system network that implements the aircraft situation display (ASD) and monitor alert (MA) functions developed by the ATMS research and development program. New computer systems with color graphics work stations have also been provided to CFCF, TMUs, and the FAA Technical Center, which interface with the Central Flow Control Computer (CFCC), the Host computers, and the ETMS computers, to provide enhanced information displays and near real-time flight data. The Arrival Sequencing Program (ASP) and En Route Spacing Program (ESP) Package 1 metering enhancements to the Host computers have also been provided.

Continuing Phase II activities are focused on replacing the CFCC, completing implementation of ASD and MA functions in all en route centers, implementing ASP and ESP Package 2 on the Host computer, and providing stand-alone monitors in CFCF and the TMUs to display weather products.

Follow-on activities to Phase 2 will include providing automation equipment to non-en route facilities, relocating the ETMS computers from the development location to an FAA facility (NAMFAC), providing an enhanced high data rate interface between the HOST and ETMS computers, and integrating DSP into the TMS. Other activities will include implementing ATMS functions on the ETMS, providing TMS hardware and software in the AAS timeframe until the next generation TMS becomes operational, and improving traffic management performance analysis capabilities by developing standards, procedures, and tools to facilitate the accurate reporting, collection, and analysis of NAS data.

Products

- One Air Traffic Control Command Center comprised of a CFCF, CARF, ARF, CFWSU and a central altitude reservations function located in FOB-10A, Washington, D.C. The TMS computer complex is located at the FAATC. ETMS computers are located at TSC, Cambridge, Mass.
- One computer program suitable for adoption and use at 20 domestic ARTCC's and selected TRACON's.

F.3.5 LORAN-C Systems

Contact Person: Rial Sloan, 202/267-3380

Purpose

To conduct necessary procurement and implementation projects to meet FAA responsibilities for the use of LORAN-C in the NAS.

LORAN-C is the Government's navigation aid for coastal areas of the United States. Signal coverage extends inland over about two-thirds of the mainland, southwestern Alaska, and Hawaii. Low-cost avionics have made LORAN-C an attractive area navigation aid for general aviation; it has been approved for en route and non-precision approach use under instrument conditions. Two goals remain to bring LORAN-C into maximum use in the NAS as a supplemental aid: (1) completion of mid-continent signal coverage, and (2) installation of signal monitors to support non-precision approaches throughout the NAS.

Products

- LORAN-C Signal Monitor System
- LORAN-C mid-continent transmitters

F.3.6 Automatic Dependent Surveillance

Responsible Division: ARD-100
Contact Person: Peter Massoglia, 202/267-8663

Purpose

To support the development and implementation of an automatic dependent surveillance (ADS) function to improve safety and provide economic benefits to users of oceanic airspace, with evolutionary applications to domestic airspace.

The ADS function will provide for improvement in tactical and strategic control of aircraft. Automated position report processing and analysis will result in nearly real-time monitoring of aircraft movement. The capability of ADS to provide timely and high-integrity aircraft position data via a satellite air/ground data link will permit possible reduction in separation standards, as well as increased accommodation of user-preferred routes and trajectories.

The program will be developed in incremental steps, with the first step being the ADS capability. The second step will add the two-way digital data communications for air traffic command and control. Follow-on steps will add additional features, including digital voice, all leading to a safer and more efficient use of the airspace.

Progress/Activity

Implementation of ADS will be at the Oakland and New York Centers only. Step 1 is scheduled for 1991 and Step 2 for 1993.

Products

- ADS Step 1 mod. operational on ODAPS SDF
- Perform Pre-Operational Trials
- Complete Step 2 Requirements Definition
- ADS Step 1 installed at Oakland & New York
- Complete Step 2 Operational Concepts and System Specification
- ADS Step 2 mod. operational on ODAPS SDF
- Complete display enhancements to ADS
- Complete integration and validation of Step 2 mod on SDF
- Complete avionics development support
- ADS Step 2 installed at Oakland and New York
- Complete advanced satellite tests
- Commence ADS integration into AAS
- Complete Laboratory and Flight Test

F.3.7 En Route Separation Standards

Responsible Division: ARD-300
Contact Person: Jerry W. Bradley, 202/267-9850

Purpose

To provide quantitative guidance for domestic and international decision making concerning adequate minimum safe horizontal and vertical separation standards.

A framework is provided for examining the tradeoffs between establishing such requirements and the capacity and economic benefits associated with improved separation.

Approach

Quantitative guidance based on statistical analysis is provided to support decision making to reduce vertical and horizontal (lateral and longitudinal) separation requirements. This activity consists of model development, data collections, data reduction, and analysis. It also includes: (1) the investigation of the effect on separation standards of imposing tighter required navigational performance specifications, (2) determinations of the effect of tolerating mixtures in the total aircraft population of both old and new specifications, and (3) investigations of the potential for the safe improvement of separation requirements in a system with advanced future navigation systems. These analyses include considerations of the role of pilot and controller, and their feedback loop process in evaluating navigational performance within the framework of collision risk methodology. This program also provides support in developing and establishing methods and procedures for monitoring standards compliance and safety.

This effort will also help establish separation requirements based on Automatic Dependent Surveillance (ADS), Area Navigation (RNAV), and other developing technologies for supporting reduced permissible separation minima.

The oceanic horizontal separation standards program will analyze separation standards in the North Atlantic, Central East Pacific, North Pacific, and West Atlantic route systems. It will examine the impact of various system improvements on safe minimal horizontal and longitudinal spacings for oceanic traffic. As oceanic control becomes increasingly flexible through automation, this program will establish appropriate separation standards to facilitate maximum traffic efficiency and safety.

Onboard, time-based navigation capabilities and associated ATC capabilities will be specifically analyzed in an effort to study the feasibility of time-based separation standards.

The vertical separation program will determine the practical feasibility of reducing the vertical separation minimum between FL 290 and FL410 from 2,000 to 1,000 feet, thus adding six additional flight levels in this altitude range. This change would provide the ATC system with enhanced flexibility to accommodate user-preferred flight profiles, and would lead to substantial savings in user fuel costs.

Progress/Activity

In FY 1990, program efforts provided leadership in completion of draft ICAO guidance material on worldwide and regional application of a 1000-foot vertical separation standard above FL290, completing an initiative begun in FY 1989. Further activities in FY 1990 will result in development of a data package to support rulemaking on this separation standards change in U.S. domestic airspace. During FY 1991, finalized ICAO guidance material will be produced and system performance monitoring techniques investigated.

In FY 1989, draft material for worldwide RNAV procedures was completed and submitted

to ICAO. This information is being combined with that from other countries and integrated with the Required Navigation Performance Capability (RNPC) concept for review during FY 1990 and 1991. This effort supported the ICAO Review of General Concepts of Separation Panel (RGCSP), North Atlantic Special Planning Group (NATSPG), and other special groups in FY 1989. This support will continue in FY 1990 and 1991.

In FY 1989, an effort was initiated to develop revised oceanic separation standards based on ADS. In FY 1990, a data collection plan will be developed and coordinated with the airline community. Data collection will be initiated as aircraft are equipped with ADS capability.

Products

Horizontal Separation Standards

- Reports on the feasibility of reduced horizontal separation in oceanic airspace
- Reports on simulation and test results for reduced horizontal oceanic separations
- Data packages for international coordination of horizontal oceanic separation standards

Vertical Separation Standards

- Data analysis and operational tests and evaluation of reduced vertical separation
- Recommendations for rule making on vertical separation standards
- Input to ICAO documents

F.3.8 Advanced Traffic Management System (ATMS)

Responsible Division: ANA-130
Contact Person: Harry B. Kane, 202/267-8336

Purpose

To reduce delays and improve operating efficiencies by developing an automated traffic management system to evaluate and specify concepts and functions that match demand to available capacity.

The ATMS is a research and development system used to investigate methods for enhancing traffic management capabilities. The ATMS is used to investigate methods of providing more precise information to system operators and users on current and projected congestion conditions. Functions developed are discrete, allowing for incremental operational implementation. ATMS will prototype the capabilities to accurately monitor the aviation system, provide alerts on projected congestion, generate alternative traffic management strategies, and distribute associated flow directives to ATC facilities. New functions are evaluated as they are added to the ATMS. Based on favorable evaluations, they are incorporated into the Enhanced Traffic Management System (ETMS) for operational use.

Progress/Activity

The Aircraft Situation Display (ASD) was developed by ATMS, and is currently being deployed as part of ETMS at the Central Flow Control Facility (CFCF), all ARTCCs, and selected TRACONs. The Monitor Alert (MA) function was also developed by ATMS, and is currently undergoing evaluation at the CFCF.

The automated demand resolution function will automatically provide traffic management alternatives for resolving identified imbalances between demand and capacity. These alternatives, which may include re-routings, flow-rate adjustments, or ground delays, will enable the traffic management specialist or automated system to select the flow strategy that best achieves the desired overall system performance. Prototype algorithms for this function will be designed and incorporated into the ATMS for evaluation in FY 1990. During FY 1990 and 1991, these algorithms will be tested and refined. When completed, these new products will be available for incorporation into the operational ETMS.

The Strategy Evaluation function was initiated during FY 1989. The design of the necessary software will continue in FY 1990, and will be incorporated in the ATMS for evaluation in FY 1991.

The design of the Directive Distribution function to provide automated distribution of flow management directives will be initiated in FY 1991.

Additional improvements to the source data used for ATMS modeling will also be under way in FY 1991 to improve the ATMS predictive and demand resolution of algorithms.

An oceanic traffic management study will be initiated in 1990 and continued through FY 1991. It specifically addresses flow management issues related to oceanic airspace. Functional and operational requirements for improved oceanic traffic management will be defined, working toward an integrated domestic and oceanic flow management system.

Products

- Design documentation for the Aircraft Situation Display (ASD)
- Design documentation for the monitor-alert function
- Design documentation for the strategy-evaluation function
- Design documentation for the automated message-distribution function
- Functional specification for the ATMS
- Concept for oceanic flow management

F.3.9 Automated En Route ATC (AERA II)

Contact Person:
Stan Pszczolkowski, 609/484-6844

Purpose

To provide interactive software for use by the Area Control Facility (ACF) in planning and monitoring the four-dimensional flow of air traffic.

Specifically, AERA will (1) assist the ATC system in permitting most aircraft on Instrument Flight Rules (IFR) flight plans to fly their preferred trajectories in the system, (2) increase the safety of the system by reducing the potential for operational errors, and (3) enhance controller productivity by increasing the number of aircraft and volume of airspace that a control team can safely manage.

AERA 2 will extend AERA 1 functions from the detection of potential conflicts to providing controllers with conflict resolution. It will also introduce the concept of computer-generated, controller-approved clearances for transmission via data link. The conflict resolution algorithms of AERA 2 will be evaluated through simulation of a variety of conflict situations, including multiple aircraft encounters. Controller interface requirements for the conflict resolution function will be developed through simulations with display mock-ups. These simulations will also identify the information the controller needs and that must be provided to the system.

The results of the above simulations will lead to detailed algorithmic and Computer Human Interface (CHI) specifications given to the AAS contractor. The AAS contractor will take the specifications and produce the AERA 2 software and integrate the software into the Area Control Computer Complex (ACCC). The AAS contractor will also provide an AERA 2 Evaluation Facility at the Technical Center to be used for evaluating AERA 2 in a full fidelity, simulated, multi-sector environment. Following the evaluations at the Technical Center, the AERA 2 Software will undergo Operational Testing and Evaluation (OT&E) and then be installed in the field.

Progress/Activity

• AERA 2 Draft Functional/ Performance Specifications completed	12/85
• Final AERA 2 System-Level Functional/Performance Specification handed off to Advanced Programs Office	6/86
• Completed AERA 2 program replan	1/88
• Mod to AAS contract issued for AERA 2 engineering study	8/89
• Final AERA 2 System Level Specification complete	12/89

Products

• AERA 2 System Level Specification	12/89
• AERA 2 Operational Description	5/90
• AERA 2 Algorithmic Specification	6/1/90
• AERA 2 Computer Human Interface Specification	6/1/90
• AERA 2 Delivered to FAA Technical Center	8/1/94
• Deliver AERA 2 to 1st site	5/15/98
• AERA 2 SITE 1(st) Operational Readiness Demonstration (ORD)	2/15/99
• AERA 2 SITE 23 (LAST) Operational Readiness Demonstration (ORD)	2/1/00

F.4 Airport Capacity Related Projects

F.4.1 Wake Vortex Avoidance Advisory System

F.4.2 Airport Capacity Task Force Studies

F.4.3 System Capacity Enhancement Planning

F.4.4 Terminal/Landside Traffic Modeling

F.4.5 Supplemental Landing System (ILS)

F.4.6 New Denver Airport

F.4.7 Low-Level Wind Sheer Alert System (LLWAS)

F.4.8 VORTAC Program

F.4.9 Microwave Landing System (MLS)

F.4.10 Runway Visual Range (RVR) Systems

F.4.11 Reduced Runway Occupancy Time (ROT)

F.4.12 Visual NAVAIDS

F.4.13 Precision Runway Monitor for Closely Spaced And Converging Runways

F.4.14 Airport Capacity Improvements

F.4.15 Airport Surface Visual Control (Lighting)

F.4.16 Pavement Strength, Durability, and Repair

F.4.1 Wake-Vortex Avoidance/ Advisory System

Responsible Division: ACD-100
Contact Person: Rick Page, 609/484-4129

Purpose

To reduce or minimize the adverse effects of aircraft trailing vortices on the flow of air traffic, particularly arrivals, thereby safely increasing airport capacity.

The generalized approach to accomplish the program objectives will include a review of previous efforts related to the development, test, and evaluation of the vortex advisory system. Develop concept for an enhanced vortex advisory system. Aircraft classification/separation standards will be reviewed and recommendations will be made for their updating. Characterizations of the wake vortices for the new generation aircraft (e.g., 757, 767, A-300) will be developed. NASA will support the FAA in the continuation of their research activities in areas of airborne detection and alleviation.

Progress/Activity

In FY 1990, a feasibility study was initiated to determine the possible use of Low-Level Windshear Alert System (LLWAS) wind information (velocity and direction) by the Enhanced Vortex Advisory System (EVAS). Efforts to characterize the vortex of new generation aircraft and vortex movement will be initiated in FY 1990. This data will be used as input for re-evaluating separation and classification standards for aircraft and separation requirements for parallel and intersecting runways respectively.

In FY 1992, a EVAS system will be deployed at an airport to demonstrate the effectiveness of an advisory system in addressing the vortex hazard issue and updating in-trail separation standards.

The data derived from these efforts will serve as the basis for new or revised aircraft classification and separation standards, new or modified separation requirements for parallel and intersecting runways, and provide the controllers with an advisory system for predicting the presence of aircraft vortices in the airport approach/departure corridors.

During FY 1991, the meteorological factors affecting the wake vortex behavior will be identified, and a report issued. In FY 1992, depending on the outcome of the aforementioned report, this concept will be further developed through field testing. Data will be collected and analyzed to investigate varying aircraft spacing as a function of weather conditions.

Products

- Classification of new generation aircraft
- Enhanced Vortex Advisory System (EVAS)
- Recommendations for aircraft separation standards and classification standards
- T-Tail Wake Vortex Study
- Recommended separation requirements for parallel and intersecting runways

NASA will be requested to perform the following:

- Development of vortex hazard models for generator and encountering aircraft
- Develop an airborne detection system
- Study methods for vortex alleviation at the source

F.4.2 Airport Capacity Task Force Studies

Responsible Division: ASC-100
Contact Person:
James McMahon, 202/267-3784

Purpose

To establish a forum, sponsored and supported by the FAA, in which airport management, the local FAA, airlines, commuters, industry groups, and airport planning consultants work together to develop technically feasible alternatives for improving airport capacity and reducing delay.

Task forces have been established at airports where the need for capacity improvement is identified. They typically investigate application of new air traffic control procedures, navigation aids, system installations, airport development, and other prospective capacity improvements. Alternatives are then evaluated using state-of-the-art simulations. The simulations provide a measure of benefit in terms of hours of delay reduction, and allow the FAA to refine modeling techniques while gaining operational benefits through assistance to the task forces.

Progress/Activity

During FY 1990, airport capacity task-force efforts were successfully completed in Boston, Salt Lake City, Washington-Dulles, Seattle, Orlando, and Chicago. Task forces are also in progress at six other locations. New runways are being planned at Atlanta, Detroit, Kansas City, Orlando, Phoenix, St. Louis, and Washington-Dulles as a direct result of airport capacity task-force efforts.

Completed task-force studies resulted in over 175 recommendations in FY 1989, 20 of which have been implemented with a total potential delay savings of more than 70,000 hours. Seventeen additional airport improvements are under construction. Action plans from each task force are assisting the FAA and the respective airports in planning and implementing capacity improvements; over 300 proposals for enhancing capacity have been developed for analysis by the task forces. An additional six task-force studies will be started in FY 1991.

Products

- Action plans incorporating the projects and programs that produce capacity improvements and delay reductions at airports under study
- Analysis of airport capacity

F.4.3 System Capacity Enhancement Planning

Responsible Division: ASC-100
Contact Person:
James McMahon, 202/267-3784

Purpose

To identify potential capacity enhancements and their benefits, develop methods to implement new technology, and report on the status of new system capacity initiatives and collect and analyze data on the nation's capacity problems, prepare the Aviation System Capacity Plan, and survey locations for applications of new technology.

The planning process is a continuous one, adapted as necessary to respond to changes in available system capacity.

Progress/Activity

During 1989, the annual Airport Capacity Enhancement Plan was published, identifying approaches to improve airport capacity at the nation's 100 largest airports, as well as identifying benefits that may also be realized at these and other airports. The plan focuses attention on needed airport and airspace improvements and the status of measures anticipated by the FAA to increase capacity. Capacity planning also includes the identification of future research requirements, goals, and objectives. In FY 1990 and 1991, the FAA will issue the first Aviation System Capacity Plan, which will integrate airport and airspace capacity analyses. Discussions of the benefits of new technology, Facilities and Equipment needs, and procedures to enhance capacity, will be included as well.

Products

- Aviation System Capacity Plan
- Technical analysis of capacity benefits with new goals and objectives for airport and system capacity RE&D

F.4.4 Terminal/Landslide Traffic Modeling

Responsible Division: APP-400
Contact Person: Larry Kiernan, 202/267-3451

Purpose

To develop microcomputer-based simulation models with graphic output for use in modeling airport terminal buildings to alleviate congestion and optimize design.

This program will develop a series of simulation models for use in planning airport passenger terminals and ground access. These models will analyze pedestrian flow through terminals and related areas as an aid in estimating space and access requirements. Commercial software will be evaluated to determine whether it meets agency requirements. Modifications or new software may then by developed.

There is a significant need to improve and enhance the capacity of airports on the airside, ground side, and in terminal areas, as well as the combined capacity of all these components. Some airports have efficient airside designs and poor terminal designs, while others have better terminal designs than airside. For any airport to operate efficiently, these elements need to be planned and constructed in combination, as an integrated design solution. The FAA currently has high-technology computer simulations available, which can be used to evaluate airport terminal designs with efficiency. These standardized, readily accessible simulation programs will be useful tools to architects, engineers, and planners involved in terminal design and expansion. Simulations also will aid airport operators in evaluating terminal improvement options and planning for expansion.

Progress/Activity

During FY 1989, several strategic models were reviewed and analyzed. Based on the results of the review an expert group was convened to establish operating characteristics of a standard terminal design model. During FY 1990, the preliminary design of the model was completed. Additionally, standard evaluation criteria were documented.

In FY 1991, we will initiate development of software for a prototype system. In addition, work will begin on the evaluation of airport-access models to simulate ground systems, high-speed rails, and remote terminals.

Products

- Public-domain microcomputer software
- User manuals

F.4.5 Supplemental Landing System (ILS)

Contact Person: Frank Roepcke, 202/267-8518

Purpose

To replace tube-type ILS equipment, complete the ILS establishment program, and provide Remote Maintenance Monitoring for ILS.

The ILS program entails the establishment of full and partial instrument landing systems at those locations that were submitted by the regions, and validated by AVS, as being qualified in accordance with criteria specified in the current FAA policy statement that allows for ILS establishment only at those locations previously qualified that do not have a precision landing system, or at those locations that have an immediate critical need and are cost beneficial. Many systems have been installed in the past that used vacuum tubes; these systems, some over 30 years old are becoming difficult and costly to maintain. A significant portion of this program deals with the replacement of the majority of the tube-type systems with solid-state equipment.

Products

- One hundred and forty-one (141) full and partial replacement instrument landing systems
- Two hundred and five (205) full and partial establishment instrument landing systems (FY-79 through FY-82)
- Reprogramming request awaiting congressional approval for additional procurement of eleven full and partial systems for establishment and seventy (75) replacement systems
- Congress has mandated the additional establishment of six (6) full and partial systems in the FY-85 appropriation
- Provide retrofit Remote Maintenance Monitoring (RMM) for all solid state ILS systems

F.4.6 New Denver Airport

Contact Person:
Peter Challan, 202/267-7335
Tom Busker,(FTS) 446-2798

Purpose

To build a major new international airport to replace Stapleton.

This project provides for the establishment of new, and modernization/relocation of existing, systems, facilities and equipment to support the operation of the new airport. The new airport will allow for increased capacity and efficiency of aircraft operations to support the growing needs of the air transportation system.

Denver currently ranks fifth in the nation in volume (enplanements and operations) of aircraft. Based upon forecasted growth over the next 10 years, the airport will reach saturation, and delays will be unacceptable during peak traffic periods. During adverse weather conditions, the acceptable operations rate at Stapleton is reduced to approximately one-half the rates attainable during visual procedures. Completion of the new Denver airport will be a major step towards increasing airport capacity and decreasing delays throughout the NAS. FAA computer modeling projects the new airport will reduce air traffic arrival delays in 1995 by: system wide — 49%; at individual connecting airports by as much as 16%; and at Denver between 35% and 55%, dependent on weather. These delay reductions translate to approximately $500 million annual savings in operating and passenger delay costs.

Products

- FAA facilities and equipment to meet the navigation and operation requirements of the new Denver International Airport

F.4.7 Low-Level Wind Shear Alert System (LLWAS)

Contact Person:
George McConnell, 202/267-8671

Purpose

To monitor winds in the terminal area and alert the pilot, through the air traffic controller, when hazardous windshear conditions are detected.

Severe windshear conditions occurring at low altitude in the terminal area are hazardous to aircraft encountering them during takeoff or final approach.

Progress/Activity

The LLWAS program was initiated early in 1975. Among the sensors evaluated were pressure jump detectors, pulsed and CW Lasers, acoustic doppler systems, pulsed doppler radar and arrays of anemometers. The last technique was selected as the most cost-effective approach. Doppler radar promised the best capability, but the technology was not sufficiently mature and the cost/techniques risks were high. Full-scale development began in 1976, resulting in the evaluation of LLWAS at six airports. Production was initiated in 1978 and, to date, 104 LLWAS units are now operating.

Products

- One-hundred and ten production systems, including spares, training, and documentation

F.4.8 VORTAC Program

Responsible Division: ANN-130
Contact Person:
John M. Williams, 202/267-6553

Purpose

To replace tube-type VOR and VORTAC equipment, and to establish/relocate sites in response to identified needs.

During the period FY-1978-1982, the FAA budgeted to replace all existing vacuum tube VOR and VORTAC systems with modern solid-state equipment. This new equipment is currently under contract. Operational requirements that arise in various geographic areas sometimes necessitate FAA increasing system capacity by establishing new VHF navigational aid sites. Also, due to operational decline of sites, route structure changes or real estate considerations, it becomes necessary to relocate facilities as required.

The present civil en route navigation system consists of VHF omniranges (VOR), a radio station that provides point-to-point azimuth guidance. Distance information is obtained from distance measuring equipment (DME). Military aircraft use a UHF tactical air navigation system (TACAN) for azimuth guidance. Air routes may be thought of as line segments connecting these various navigation facilities.

Products

- 725 VORTACs
- 145 VOR/DMEs
- 80 VORs
- 303 RMC-F (remote monitor and control at FSS)
- 25 RMC-C (remote monitor and control at ARTCC)
- 113 VOTs (VOR test facilities)
- 50 Doppler VOR conversions (option for 40)

F.4.9 Microwave Landing System (MLS)

Responsible Division: AND-30
Contact Person: Richard Arnold, 202/267-8709

Purpose

To develop and implement a new common civil/military approach and landing system that will meet the full range of user operational requirements well into the future.

This system will be the international standard replacement for the current Instrument Landing System (ILS).

The approach to accomplish the program objectives concentrates as much on the user issues as on the technical issues. The international requirements for this system are on a firm foundation and there are vendors in several countries that manufacture at least the Category I version of the MLS. There are also several manufacturers of the basic avionics sets. The users at this time are questioning the benefits of equipping with MLS given the alternatives of improvements in the ILS, and the potential use of satellite-based systems for precision approaches. In December 1988, OST approved a new MLS implementation strategy and a nine-point demonstration program to ascertain the economic and operational benefits of MLS.

Progress/Activity

All nine evaluation activities within the demonstration program were initiated in FY 1990. The program to compare the frequency congestion potential of MLS and ILS is ahead of schedule, and is able to identify sources of in-band interference. Advanced approach procedures in wide body aircraft has gotten favorable ratings from the airline crews flying very short final curved segments in a 747 simulator. The simulation of advanced procedures in a multi-airport environment is investigating the benefits of complex approaches to airports in the New York area. To evaluate the general aviation/commuter capacity enhancements, MLSs will be installed at JFK and Chicago Midway. Extensive work has been accomplished on ILS/MLS technical comparisons. Several activities focusing on minima reductions are underway including assessments of decision height and other MLS TERPS standards. A contract has been awarded to design a DME/P interrogator which will be used as part of the evaluation program, and then be made available to other manufacturers. MLS avionics costs will be analyzed for all categories of aircraft. Activity is underway to work with a major aircraft manufacturer to certify an entire class of aircraft for MLS Category III operations.

The 1984 contract with Hazeltine to produce and install 178 Category I MLSs was terminated in August 1989 for failure to perform and deliver in accordance with the contract schedule. This contract represented less than 14 percent of the FAA's requirement for 1250 MLSs to replace the ILSs. A second procurement of 950-1000 Category II/III systems will occur at the successful conclusion of the demonstration program. A draft of the specification for a prototype procurement for this system has been reviewed by industry, and the request for proposal will be issued this year.

To meet the demand for MLSs for the operational and economic evaluations of MLS benefits, up to 26 FAR Part 171 Category I MLSs will be procured. The contract has been awarded for this procurement.

The FAA's transition plan will provide an MLS at every commissioned ILS location until parity is reached, at which time the MLS will become the primary system in the United States. Following a reasonable time period to allow the air carriers to equip, ILS systems will be decommissioned in a structured, coordinated fashion.

Products

- Up to 26 FAR Part 171 Category I MLSs
- A DME/P interrogator design
- Demonstrations of the MLS's operational and economic benefits from the nine-point evaluation program
- Between 950 and 1000 Category II/III MLSs delivered from 1995 to 1999 with our international commitments met by January 1998
- Modifications to TERPS and approach procedures to effectively integrate MLS into the ATC system

F.4.10 Runway Visual Range (RVR) Systems

Contact Person: Charles Ochoa, 202/267-7507

Purpose

To establish and modernize existing Runway Visual Range (RVR) systems on qualifying Category I, II, III a/b ILS and MLS runways. RVRs support precision approach landing operations.

RVR equipment provides real time measurement of visual range along the runway. The RVRs in the NAS utilize old technology and cannot be economically upgraded to satisfy the requirements of the NAS in the 1990's and beyond. A new generation RVR has been conceived to economically satisfy all future NAS operating and maintenance requirements.

Products

- 700 RVR systems with proper documentation

F.4.11 Airport Capacity and Delay — Reduced Runway Occupancy Time (ROT)

Responsible Division: ARD-200
Contact Person: Hisao Tomita, 202/267-8697

Purpose

To improve airport designs to reduce runway occupancy and taxiing time; enhance aircraft ground operations by providing reliable information on runway snow and slush depths and timely removal of snow and ice; and improve the airport safety zone by developing design criteria for soft-ground overrun systems.

Progress/Activity

Studies will be conducted to improve airport design and configuration to decrease runway occupancy time and taxiing time from runways to gates and back to runways; an increase in airport capacity is expected to result from these studies. In addition, current and improved airport designs and configurations will be evaluated for compatibility with new aircraft. Improved slush and snow detection/measurement systems, with methods to report conditions to air traffic control (ATC) towers and airport operations offices, will be evaluated. Improved de-icing and anti-icing chemicals and abrasives will be assessed to determine the optimum application rate needed to minimize runway downtime during removal operations.

The development of the exit algorithm and computer program for exit design using personal computers was completed in FY 1989. Simulator evaluation of the exit designs was initiated in FY 1989 and will continue in FY 1990 and 1991. An exit design was completed for demonstration at a specific airport in FY 1990. In FY 1991, simulator evaluation of exit designs will continue, and acceptable designs will be provided for demonstration at additional airports under the Airport/Microwave Landing System Demonstration Program.

In FY 1989, evaluation of current and improved exit and taxiway designs was initiated. An airfield simulation model will be used to perform capacity (flow rate) analyses of representative samples of current designs. Improvements will be incorporated in the designs, including multiple exists, multi-lane taxiways and crossovers, and aircraft holding areas near runway ends. The improved designs will be reanalyzed for capacity and compared to original flow rates for capacity gains. The evaluation will continue in FY 1990 and 1991.

In FY 1989, contracts with airports using ice sensors were initiated to obtain performance information, and will be completed in FY 1990. The laboratory evaluation of a pavement ice and water monitor was completed in FY 1989. Laboratory evaluation of a vibro-meter sensor was initiated in FY 1989 and will continue in FY 1990. In FY 1990 and 1991, work on improved slush and snow detection and measurement will continue to study systems with methods of transmitting data to ATC towers and airport operations offices. This effort will be completed in FY 1992, and improvements in the management of airports in snow and slush removals are expected as a result.

A second series of field evaluations was completed in FY 1989 on five improved de-icing chemicals at the U.S. Naval Air Station in Brunswick, Maine. Field evaluation of improved de-icing and anti-icing chemicals and abrasives will continue in FY 1990 and 1991, and will be completed in FY 1992. In addition, laboratory tests will be initiated in FY 1990 for toxicity and corrosion, which will be completed in FY 1991.

In FY 1989, design of the fixture to be mounted on a test cart was completed, and the fabrication of the fixture was initiated for the experimental program. Development of design criteria for soft-ground arresting systems will be completed for foam systems in FY 1991. An

experimental program to verify theoretical stopping distances in foam will be completed in FY 1990, and will continue for gravel and sand in FY 1991.

In FY 1990, analyses of current airport designs for compatibility with new aircraft will be initiated, and will be completed in FY 1991. Requirements for clearances, fillets, curves, and aprons are considered in this work. Results will be used to recommend improvements in airport designs.

Products

- Technical reports
- Computer programs and user guides
- Design criteria and guidelines for airports
- Test methods and procedures
- Analysis methods

F.4.12 Visual NAVAIDS

Contact Person: Charles Ochoa, 202/267-7507

Purpose:

To provide safety-related facilities and enhancements at airports.

The facilities to be provided are: medium intensity approach lighting system with runway alignment indicator lights (MALSR), runway-end identification lights (REIL), visual approach slope indicator (VASI) or precision approach path indicator (PAPI), and omnidirectional airport lighting system (ODALS).

This program also includes the retrofitting of remote radio controls for visual aids to meet the operational requirements of air traffic controllers. The new system will permit single-button control of each visual-aid function.

The establishment of visual navaids projects are based on each region submitting qualified candidates. In addition, the President's Task Force on aircrew complement recommended the installation of vertical guidance capability at all air carrier runways, and those locations not equipped with vertical guidance devices will receive priority consideration.

Products

Quantities vary from year to year depending upon the urgency of the requirement, validation of requirements, and availability of funds. The radio control retrofit program will involve 1,348 airports, having a total of 3,032 visual aids.

F.4.13 Precision Runway Monitor for Closely Spaced and Converging Runways

Responsible Division: ARD-300
Contact Person: Ken Byram, 202/267-3082

Purpose

To assess the feasibility of applying a faster, more accurate radar to increase the aircraft arrival rate at airports with converging or closely spaced parallel runways, and develop the necessary equipment.

An airport's capacity to handle arriving aircraft is limited by the number of runways that are usable at one time. In instrument meteorological conditions (IMC), controllers must maintain a minimum distance between two aircraft landing on parallel runways. The distance specified by today's procedures is based on a number of factors, including the precision of the pilot's navigational capability, the accuracy and speed of the radar surveillance available to the controller monitoring approaches, and the reaction time for controller, pilot, and airplane should one aircraft "blunder" toward the other. A similar but more complicated set of constraints limits the number of aircraft approaching multiple, non-parallel ("converging") runways.

This project will demonstrate the increases in an airport's arrival capacity that are possible with enhanced radar and controller displays. It will also produce a series of measurements on pilot navigational accuracy, effect of weather, effect of the distance between the parallel runways, the utility of predictive displays, and response times of controllers, pilots, and aircraft. These measurements will also be useful in other similar applications such as triple and quadruple parallel runways.

Progress/Activity

Two technical approaches are being verified, both using secondary beacon radar. Each has achieved about a tenfold improvement over today's systems. At the Raleigh-Durham Airport, an electronically scanned (E-Scan) beacon radar is being tested for the first time in an air traffic control application. This system is capable of a 0.5 second update interval, compared with a 4.8 second update interval available from today's radars. An engineering model of this radar was delivered and tested in 1989. It will be ready for demonstrations in January 1990. An upgrade to operational status is expected by July 1991, with subsequent units available in 1993. Specifications for the operational upgrade were prepared in 1989, and a production specification will be prepared in 1990.

At Memphis, a 2.4 second update interval is obtained using Mode S monopulse processing on back-to-back beacon antennas mounted on a conventionally rotating ASR system. The engineering model was delivered in 1988, and, during 1989, data collection on IFR approaches took place at Memphis. These data will be used as input to models that characterize flight performance to an accuracy not previously available. An operational configuration of the Mode S ground system awaits deployment, and subsequent modification is to be ready in 1993.

The demonstrations of both E-Scan and Mode S, beginning January 1990, will use improved 20 by 20 inch displays that were acquired and programmed in 1989. The demonstrations include human controllers monitoring parallel approaches conducted by pilots flying both actual aircraft and B727 and MD80 flight simulators. Computer simulated targets programmed from the data collected at Memphis will also be used. The demonstrations may be continued in 1991 to include converging runways, and simulated triple and quadruple parallel runways.

Specifications, both for the modifications to the Mode S system and for the production E-Scan systems, will be prepared in 1990. Implementation of the E-Scan system is at greater cost than implementation of the Mode S, but provides a faster update rate. Which update rate is suitable at which airports is an expected outcome of the demonstration. Procurement schedules will be finalized at that time.

Products

- Operational requirements definition
- Automatic blunder-detection algorithms
- Database of parallel-approach aircraft trajectories
- Validated runway separation safety model
- Measured performance of alternative sensors, displays, and blunder-detection algorithms
- Procurement specification for production sensors or sensor modifications
- Operational procedures and guidelines
- Evaluation of high and medium data-rate sensor system designs

F.4.14 Airport Capacity Improvements

Responsible Division: ARD-200
Contact Person: Gene Wong, 202/267-3475

Purpose

To develop ATC concepts and procedures to reduce airport delays, more fully utilizing the Instrument Meteorological Conditions (IMC) capacity of multiple runway configurations.

Air traffic procedures and flight standards criteria for simultaneous triple and quadruple Instrument Flight Rules (IFR) parallel approaches will be developed and validated. Requirements and techniques for improved surveillance and navigation capabilities will be developed to support these procedures.

Studies sponsored by the FAA and the aviation industry have identified operational concepts with the potential to reduce airport arrival delays by better utilizing multiple runway configurations in IMC. These concepts include simultaneous and independent IFR parallel approaches to triple and quadruple runways, as well as converging runways. ATC procedures and associated navigation and surveillance techniques for implementing the triple and quadruple IFR parallel approaches need to be developed. Promising concepts will be further explored and validated through ATC simulations and, in some cases, full-scale demonstrations at airports.

Initially, multiple IFR parallel approach procedures for a specific airport are developed in order to gain technical and operational insights, as well as to help expedite the implementation of such procedures at the selected airport. Dallas/Fort Worth Airport, with the planned additions of the third and fourth arrival parallel runways, has been selected for procedure development and validation. This will be followed by the development of national standards for triple and quadruple IFR parallel approaches based on the current Airport Surveillance Radar (ASR) capabilities. The final phase of the multiple IFR parallel-approach procedure development will focus on national standards based on the high-data-rate runway demonstration monitors being tested at Memphis and Raleigh-Durham Airports.

Progress/Activity

In FY 1990, simulation evaluation of simultaneous IFR approaches to the proposed triple and quadruple parallel runways at Dallas/Ft. Worth Airport with controller participation will be completed. By FY 1991, it is anticipated that a triple parallel runway may be available at Dallas/Ft. Worth Airport for demonstration of triple IFR procedures.

By the end of 1991, simulations with controller participation for developing national standards for triple and quadruple IFR parallel approaches based on the current ASR capabilities will be completed. In 1991, analysis will continue to develop simultaneous IFR approach procedures to triple and quadruple parallel runways based on the capabilities of improved data rate runway monitors at Memphis and Raleigh-Durham airports. Proposed national standards for these multiple IFR parallel approaches will be validated through simulations.

Products

- Technical reports
- Flight procedures and system requirements for simultaneous IFR approaches to triple and quadruple parallel runways
- ATC simulations and field demonstrations of promising procedures

F.4.15 Airport Surface Visual Control (Lighting)

Responsible Division: ARD-200
Contact Person: Hisao Tomita, 202/267-8697

Purpose

To provide concepts and criteria for improved lighting, marking, and signing devices. These concepts and criteria will improve airport safety by providing better guidance in low-visibility conditions.

Progress/Activity

The efforts in this program will be accomplished by developing and testing improved lighting, marking, and signing devices for the ground guidance of aircraft at very low visibility conditions. New concepts for lighting and its energy sources, as well as self-contained systems requiring little or no maintenance, will be investigated. Tests of promising systems and concepts will be initially conducted at the FAA Technical Center. When necessary, improved systems will be validated by field tests at operational airports. Recommendations will be developed for incorporation of the improved lights, markings, and signs in the Advisory Circular.

In FY 1990, an effort was initiated to determine specifications for a lighting simulator and to further develop recommendations (in the form of a research report) for design criteria for the following visual guidance systems:

- Improved taxiway intersection lighting and marking.
- Modified touchdown-zone lighting system.
- Hold-short lighting system for Boston.
- Lighted power-line catenary warning device.
- Improved taxiway exit identifier.
- Improved circling guidance from runway lights.

Products

- Research reports and design criteria
- Lighting standards for airports

F.4.16 Pavement Strength, Durability, and Repair

Responsible Division: ARD-200
Contact Person:
Aston McLaughlin, 202/267-8694

Purpose

To provide support, through research and development, for the rule-making and advisory mission of the FAA in setting minimum acceptable standards for airport pavements.

This program concerns areas involving material quality, design, evaluation, construction, and maintenance that will assure airport pavement integrity and longevity.

The FAA sponsors research to arrest premature deterioration of pavements and to develop new or improved criteria for materials at the request of airport owners, operators, and industry groups. Surveys, studies, and tests are conducted to determine optimal limits for variables in order to assure improved pavement performance and longevity. Where necessary, laboratory investigations are performed or prototype test pavements constructed to verify findings before making recommendations for new or improved criteria.

The FAA provides guidelines on new cost-effective approaches, design and construction techniques, and methods for enhancing the strength and durability of geotechnical materials suitable for use in airport pavements. These materials must be strong enough to sustain repeated wheel loading, must be insensitive to changes in temperature and moisture, and must be free from susceptibility to frost damage and thaw-weakening. Certain polymers and resins have also been used on an experimental basis and on a limited scale. Acceptance criteria and pavement adjustment factors being developed will be field validated. This project also will investigate the use of reinforced aggregate and marginal materials for airport pavements.

In parallel with the development of better pavement materials, improved analytical techniques for pavement design and evaluation will be formulated. These techniques will provide an accurate assessment of pavement response to different aircraft wheel loadings, and will model the effects of variations in temperature and moisture on new pavement joint configurations. These analytical techniques will be programmed for computation on personal computers, and the programs will be streamlined and improved as much as possible to decrease computation time. Test methods will be developed to provide material-property parameters required by the improved analytical techniques for pavement design.

Finally, this project will develop improved methods of nondestructive structural testing, evaluation, and rehabilitation. Runway smoothness criteria that limit aircraft vertical accelerations will be established, and analytical methods will be developed to determine the deterioration of runway smoothness.

Progress/Activity

In FY 1989, a methodology was completed to provide guidance on the use of lime, cement, fly ash, and coal-tar seal coatings for airport pavements; efforts continued on quality-control and acceptance criteria. Work was initiated to develop a unified methodology for the design and evaluation of pavement strength to devise guidelines for the application of novel construction technology.

In FY 1990, studies will be conducted on the use of marginal materials and polypropylene fibers to reduce pavement wear. Efforts to develop a unified design and evaluation methodology will continue. Work also will proceed on the evaluation of a new drainage system in FY 1990 (plastic core and wrap), and this will be completed in FY 1991. New quality-control acceptance criteria will be completed and made available to appropriate airport officials. Also to be completed in FY 1990 is a study on

Nondestructive Testing (NDT) methodology and layered elastic design.

In FY 1991, new polymer fibers will be evaluated for their ability to reduce cracking, decrease maintenance costs, and provide greater strength and durability to pavement components. These binders must be cost-effective when produced in quantity, environmentally acceptable for use in construction, and energy-efficient in production and use.

Products

- Technical reports and procedures manuals
- Design and analysis software and user guides
- Test methods and NDT methodology
- Guidelines and criteria for pavement design, construction, and maintenance

Appendix G

Acronym List

AAS .... Advanced Automation System
ACCC .... Area Control Computer Complex
ACF .... Area Control Facilities
ADS .... Automatic Dependant Surveillance
AERA .... Automated En-Route Air Traffic Control
AIP .... Airport Improvement Program
ALP .... Airport Layout Plan
AMASS .... Airport Movement Area Safety System
ARF .... Airport Reservation Function
ARSA .... Airport Radar Service Area
ARTS IIIA .... Automated Radar Terminal System IIIA
ARTCC .... Air Route Traffic Control Center
ASD .... Aircraft Situation Display
ASDE .... Airport Surface Detection Equipment
ASR .... Airport Surveillance Radar
ASTA .... Airport Surface Traffic Automation
ATC .... Air Traffic Control
ATCBI .... ATC Beacon Interrogator
ATCCC .... Air Traffic Control Command Center
ATIS .... Automatic Terminal Information Service
ATMS .... Advanced Traffic Management System
ATOMS .... Air Traffic Operations Management System
AVS .... Aviation Standards Office
B-727 .... Boeing 727 Airplane
CARF .... Central Altitude Reservation Facility
CAT .... Category
CCB .... Configuration Control Board
CFCC .... Central Flow Control Computer
CFCF .... Central Flow Control Facility
CFWSU .... Central Flow Weather Service Unit
CONUS .... Continental United States
CW .... Continuous Wave
CY .... Calendar Year

DME .... Distance Measuring Equipment
DOD .... Department of Defense
DSP .... Departure Sequencing Program
DSUA .... Dynamic Special Use Airspace
DUAT .... Direct User Access Terminal
EIS .... Environmental Impact Statement
EOF .... Emergency Operation Facility
ERM .... En Route Metering
ETMS .... Enhanced Traffic Management System
EVAS .... Enhanced Vortex Advisory System
FAA .... Federal Aviation Administration
FAATC .... Federal Aviation Administration Technical Center
FDIO .... Flight Data Input/Output
FSS .... Flight Service Station
FY .... Fiscal Year (October 1 through September 30)
GA .... General Aviation
GFE .... Government-Furnished Equipment
HF .... High Frequency
ICAO .... International Civil Aviation Organization
IFCN .... Interfacility Flow Control Network
IFR .... Instrument Flight Rule
ILS .... Instrument Landing System
IMC .... Instrument Meteorological Conditions
JFK .... John F. Kennedy Airport
MALSR .... Medium Intensity Approach Lighting System with Runway Alignment Indicator Lights
MEM .... Memphis International Airport
MD 80 .... McDonnell-Douglas Aircraft
MLS .... Microwave Landing System
MWP .... Meteorologist Weather Processor
NAMFAC .... National Airspace Management Facility
NAPRS .... National Airspace Performance Reporting System
NAS .... National Airspace System
NASPAC .... National Airspace System Performance Analysis Capability
NAVAIDS .... Navigational Aids
NFDC .... National Flight Data Center
NGM .... Agana Field
nmi .... Nautical Miles

ODALS .... Omnidirectional Approach Lighting System
ODAPS .... Oceanic Display and Planning System
PAPI .... Precision Approach Path Indicator
PRM .... Precision Runway Monitor
R,E, and D .... Research, Engineering and Development
REIL .... Runway End Identifier Lights
RMM .... Remote Maintenance Monitoring
RNAV .... (Remote) Area Navigation
RVR .... Runway Visual Range
SDAT .... Sector Design Analysis Tool
SDF .... Simplified Directional Facility
SDRS .... Standardized Delay Reporting System
SIMMOD .... Airspace and Airport Simulation Model
SYS .... System
TACAN .... Tactical Air Navigation
TATCA .... Terminal ATC Automation
TCA .... Terminal Control Area
TCAS .... Traffic Alert and Collision Avoidance System
TERPS .... Terminal Instrument Procedures
TFM .... Traffic Flow Management
TMP .... Traffic Management Processor
TMS .... Traffic Management System
TMU .... Traffic Management Unit
TRACON .... Terminal Radar Approach Control
VASI .... Visual Approach Slope Indicator
VFR .... Visual Flight Rules
VOR .... VHS Omnidirectional Range
VORTAC .... Combined VOR and TACAN
VOT .... VHS Omnidirectional Range Test